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Foreign Foundry Labour

It is generally agreed that any foundry can use—if available—unskilled prisoner-of-war labour. The question of skilled labour, however, is quite otherwise. There seems to be no theoretical objection to the employment of French, Belgian or Dutch, but investigations have shown that none is available. Next on the list is that of Italian skilled labour. It seems that here there is a very large reservoir available, and at the moment discussions are taking place at the highest level as to the possibility of its employment. We have had a fair amount of experience of Italian labour, and we offer the following commentary on its potentialities. "Highly-skilled" Italian moulders are in every sense worthy of that appelation. As apprentices they are not so quick to learn as the British, but by the time they are journeymen they have thoroughly mastered their trade. Moreover, they are, generally speaking, conscientious workers and of sober habits. It should be borne in mind that builders' castings are different in Italy. There are no cast-iron gutters and fall pipes, as steel pressings are in general use in that country. The gas-cooker industry is not so highly developed, but there are available some good lines of electric ovens. Space-heating stoves, especially for the farmhouse market, are quite different from ours, and most are designed to burn wood.

Whilst we have had experience of German prisoner-of-war labour, which, we must confess, we found excellent, we have had no direct contact with German skilled labour. Obviously, we have watched them working in German foundries, where they seemed well versed in their avocation. The problem of their employment in British foundries is a dual one. Primarily, there is a general objection by the trade unions to work side by side with men against whom they rightly bear a grudge. Secondly, there is a case such as exists in Lancashire, where a large foundry is standing idle. The management of this particular concern is prepared to open the shops using nothing other than German labour, with British supervision. Such an action would obviously relieve pressure on the now overworked jobbing foundries and help in some measure to feed the machine shops. This aspect is also having the attention of the unions. Put plainly, in the own countries there is but little prospect of work for skilled moulders for several years, whereby the world will be deprived of much-needed production dependent on their skill.

Here 35,000 men are needed for the ironfoundry industry. To put it bluntly, this is a case when the head should rule the heart. We would make but one proviso—the minute the hectic demand for castings ceases, German labour must be returned to its own country.

DEATH OF MR. ROBERT WILSON

It is with regret that we announce the death, at the age of 42, of Mr. Robert Wilson, editor of our associated journal, *The Iron and Coal Trades Review*. He was appointed to the editorial chair about two years ago after being technical editor for more than a decade. He was trained in metallurgy at the Royal Technical College, Glasgow, and was for a number of years on the staff of Clyde Alloy Steel Company, Limited. Ever since his appointment as editor, Wilson had been severely handicapped by heart trouble, but he refused to rest. He died in his sleep last Monday at the National Liberal Club, where for several years he had lived.

Bob, as he was generally known, was well known in both mining and metallurgical circles, for despite the handicap of a weak heart, he managed fully to participate in the functions connected with both industries. He was a fearless and incisive writer, and his editorials commanded wide respect within the industries he served.

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FORTHCOMING EVENTS

(Secretaries are invited to send in notices of meetings, etc., for inclusion in this column.)

FEBRUARY 22.

Institute of Welding (East Scotland branch) :—"Automatic Welding," by R. R. Sillifant. At the Heriot Watt College, Chambers Street, Edinburgh, at 7.30 p.m.

Manchester Association of Engineers :—"The Manufacture and Properties of Modern High Strength Castings." Part I: "High Duty Iron," by J. J. Sheehan. Part 2: "Steel Castings," by C. H. Kain. At the Engineers' Club, Albert Square, Manchester, at 6.45 p.m.

Association for Scientific Photography :—Extraordinary general meeting, followed by "The Photographic Copying of Documents and Plans," by F. J. Tritton. At the Royal Society of Arts, John Adam Street, London, W.C.2, at 6.15 p.m.

FEBRUARY 26.

British Society for International Bibliography :—"The Principles of Alphabetical Arrangement," by A. H. Chaplin, and "An Industrial Information Department," by W. John Merrick. At the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2, at 2.30 p.m.

FEBRUARY 27.

Institute of Welding :—"The Pressure Welding of Light Alloys," by R. F. Tylecote. At the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, at 5.30 p.m.

Institute of Welding (Wolverhampton branch) :—"The Costing of Welding," by R. G. Braithwaite. At the Victoria Hotel, Wolverhampton, at 7 p.m.

MARCH 1.

Keighley Association of Engineers :—Members' discussion night. At Devonshire Buildings, Devonshire Street, Keighley, at 7.30 p.m.

Institute of Welding (South London branch) :—"Welding of Armour," by Major L. F. Denaro. At Borough Polytechnic, Borough Road, London, S.E.1.

MARCH 8.

Manchester Association of Engineers :—"Drop Forgings," by Lt.-Col. J. W. Danielsen. At the Engineers' Club, Albert Square, Manchester, at 6.45 p.m.

Institute of British Foundrymen

FEBRUARY 23.

Bristol and West of England branch :—"The Production and Application of Special Types of Cast Iron." by A. E. McRae Smith. At Gloucester.

East Midlands branch :—"Metal Shrinkage," by Dr. H. T. Angus. At the College of Technology, Leicester, at 6 p.m.

Wales and Monmouth branch :—"Consistency and the Cupola," by C. A. Payne. At the Engineers' Institute, Cardiff, at 2.30 p.m.

FEBRUARY 25.

Sheffield branch :—"Review of Sand-binding Materials and Compounds," by C. Wood. At the Royal Victoria Hotel, Sheffield, at 7 p.m.

FEBRUARY 27.

Birmingham branch :—"Magnesium Foundry Practice," by J. Partridge. At the James Watt Memorial Institute, Great Charles Street, Birmingham, 3, at 7.30 p.m.

London branch :—"Opportunities for the Foundry Technician in India," by J. Blakiston. At the Charing Cross Hotel, London, W.C.2, at 7.30 p.m.

MARCH 1.

Falkirk section :—"Patternmaking," by G. C. Wilson, and annual business meeting. At the Temperance Café, Lint Riggs, Falkirk, at 6 p.m.

MARCH 2.

Lancashire branch :—"Cupola Control," by C. A. Payne. At the Engineers' Club, Albert Square, Manchester, at 3 p.m.

MARCH 5.

Burnley section :—Annual general meeting. At the Municipal College, Ormerod Road, Burnley, at 7.30 p.m.

MARCH 9.

Scottish branch :—"The German Non-ferrous Casting Industry," by H. Ellis, and annual business meeting. At the Royal Technical College, George Street, Glasgow, at 2.45 p.m.

West Riding of Yorkshire branch :—Prize winning Paper in the S. W. Wise memorial competition. At the Technical College, Bradford, at 6.30 p.m.

Lincoln section :—"Modern Research on Cast Iron," by H. Morrogh. At the Technical College, Lincoln, at 2.45 p.m.

MARCH 23.

Bristol and West of England branch :—"The Foundry," by W. McCormick. At the Merchant Venturers' Technical College, Bristol, at 7 p.m.

Lincoln section :—"A Discussion of Problems in Jobbing Ironfoundries," by A. E. McRae Smith. At the Technical College, Lincoln, at 2.45 p.m.

MARCH 25.

Sheffield branch :—"Precision Casting by the Lost Wax Process," by Adam Dunlop. At the Royal Victoria Hotel, Sheffield, at 7 p.m.

MARCH 27.

Birmingham, Coventry and West Midlands branch :—"A Survey on the Mass Production of Small Steel Castings," by W. H. Bamford. At the James Watt Memorial Institute, Great Charles Street, Birmingham, at 7.30 p.m.

London branch :—"The Education and Recruitment of Foundrymen," by Dr. D. H. Ingall. At the Charing Cross Hotel, London, W.C.2, at 7.30 p.m.

MARCH 30.

East Midlands branch :—Annual meeting and short Paper competition. At the Technical College, Derby, at 6 p.m.

Wales and Monmouth branch :—"Production of Tank Wheels in a Mechanised Blackheart Malleable Foundry," by A. B. Bill and J. Peers. At Newport.

NEW CATALOGUES

Worm Reducers. C. J. Fitzpatrick & Company, Limited, of Stonebridge Park Works, London, N.W.10, a subsidiary company of David Brown & Sons (Huddersfield), Limited, have issued a 4-page, illustrated leaflet to detail the technical characteristics of two sizes of "Radicon" worm reducers.

Briquetted Alloys. St. Lawrence Alloys & Metals, Limited, of Beauharnois, Quebec, Canada, in Booklet 5-E make out a sound case for improving cast iron with briquetted alloys. Generally speaking, the claims made are justified, and the hints and tabular matter given are useful, but there is too little realisation that in this country builders' castings and components destined to be enamelled often carry more than 1 per cent. phosphorus. Another factor which seems a little unpractical is to give for cupola mixtures easy multiples in kilograms and difficult ones in lbs. As the former are by nature easier to deal with arithmetically, a switchround is suggested. This brochure is available to our readers on writing to Quebec.

Screw Fans. Special importance is to be attached to Publication S.F. 372, just issued by Davidson & Company, Limited, Sirocco Engineering Works, Belfast, as it illustrates and describes the sort of plant which the foundry industry will have to purchase in large quantities in the near future in order to improve working conditions. It is well garnished with technical data, but less importance should be attached to these than to the final paragraph, which promises technical assistance to "discuss requirements and advise the most suitable type of equipment." Half the book, which carries about 70 pages, is devoted to problems connected with marine applications.

THE FORMATION OF BANDED STRUCTURES IN HORIZONTAL CENTRIFUGAL CASTINGS

Notes on the examination of carefully selected examples typical of a wide range of alloys

By C. HOWSON

The process of centrifugal casting has become firmly established as an important branch of foundry work, and it has been proved both by laboratory tests and by service operation that centrifugal castings may be prepared having a high degree of mechanical strength and uniformity. Castings prepared by a rotative process frequently show a banded macrostructure after etching. On visual inspection it could be assumed that these bands might possess some intrinsic weakness giving rise to inferior mechanical properties. It is therefore important to consider the method of formation of these structures in order that the effect on the properties of the casting may be assessed.

Little work has been done along these lines until the recent Paper[1 2] by Northcott and Dickin. In this excellent report an effort is made to correlate the presence of banded structures with the degree of vibration in the casting machine. The value of the Paper is recognised in presenting a series of castings prepared under controlled conditions, but in this present Paper an effort will be made to show that the assumption of the presence of vibration is unnecessary, as in horizontal casting there is an inherent variation in mechanical force during rotation.

The first section deals with mathematical and theoretical considerations with regard to centrifugal casting, then a series of examples of castings in ferrous and non-ferrous metals will be described, and finally an attempt will be made to explain the macrostructural formations encountered. Throughout the Paper it is to be understood that in every instance horizontal casting is referred to, as it is fully appreciated that conditions in the vertical process are somewhat different.

FUNDAMENTAL CONSIDERATIONS IN CENTRIFUGAL CASTING

The Flow of Metals in a Rotating Tube

The forces acting on a solid rotating tube are capable of evaluation with an accuracy sufficient for most practical purposes, and mathematical treatment is therefore applicable to the centrifugal casting process after solidification has occurred. The calculation of the forces[3] acting on the liquid metals is, however, more complex in view of the other factors introduced. The chief difficulty arises with regard to the precise knowledge of the magnitude of the coefficient of friction between the liquid metal and the mould. It is to be assumed that the viscosity of fluid metals is a variable quantity decreasing as the *liquidus* is approached, but the form of the relationship between temperature and viscosity is conjectural. It is possible that liquid metals pass through a "mushy" stage before the *liquidus* is reached on cooling. Alternatively, the liquid metal may behave like water, that is, there is only a small reduction in viscosity on cooling until the freezing point is approached, and probably this view is correct.

It has been assumed in certain publications on centrifugal casting that when once the metal has "picked up" by the mould the liquid rotates with the same angular velocity as the mould. This view point is considered entirely untenable for the following reasons:—

(*a*) The columnar crystals in centrifugal casting always show an appreciable inclination to the normal. This indicates that the liquid metal is flowing over the deposited crystals, which can only mean that the liquid is lagging behind the solid crystals.

(*b*) If the liquid metal was rotating with the same velocity as the mould, a speed of rotation equivalent to a centrifugal force of 1G would be sufficient to maintain a complete tube form (G is the downward acting force due to gravity on a unit mass). In practice, a mould speed sufficient to develop a centrifugal force equal to approximately 55G is essential. This may be illustrated by the comparatively slow speed of movement necessary to retain water in a bucket when swung round at the full extension of the arm. This is because the water is constrained by the bucket and compelled to travel with the same velocity as the bucket. The angular velocity of the water is the same as that of the arm, and centrifugal force of magnitude sufficient to overcome gravity at the vertex position is readily developed. On the contrary, if water is introduced into a rotating cylinder of radius equal to the length of the arm, an enormously greater angular velocity is required to maintain complete tube form. This is because the angular velocity of the water is less than the mould, and is dependent on the friction between the water and the mould, and, consequently, the surface character of the mould. As the speed is reduced the force developed is not sufficient to maintain the liquid as a tube at the vertex. This results in the water cascading over before the vertex position is reached, and splashing results.

A Tangential Force

Precisely the same phenomena as outlined above have been observed in the behaviour of rotating metals in rotating moulds. It is, therefore, considered that in horizontal centrifugal casting the liquid metal is

The Formation of Banded Structures

rotated by the effect of a tangential force due to the friction between the liquid and the mould, or previously deposited crystals. No satisfactory method has been devised for determining the actual velocity of the metal. Experience has shown that this velocity is not constant for a particular mould rotating at a given speed, but is influenced by such factors as temperature (principally) inclusion and gas content of the metal, and the density of the metal It is, therefore, customary to correlate all calculations with the revolutions per minute of the mould, and with the centrifugal force in lbs. weight acting on a mass of 1 lb. placed at the bore of the mould. For example, a speed of 75G means that the centrifugal force acting on a mass of 1 lb. concentrated at, and rotating with, the mould bore would be 75 lbs. weight.

Commercial centrifugal castings are prepared at such speeds as to give a centrifugal force in the neighbourhood of this value. At lower speeds, say, about 55G, the centrifugal force developed is only sufficient to maintain a thin layer of liquid in tube form. The remainder either lies at the bottom position, or is carried round to some position approaching the vertex, and then cascades down. At higher speeds there is every indication that the metal is maintained entirely in tube form for the case of castings of quite appreciable wall thickness. The fluid metal is only in contact with the mould wall for a period in the early stages of the casting process, as a layer of crystals is quickly built up. The important factor is, therefore, the coefficient of friction between the liquid and the already formed crystals.

There are two distinct methods of flow in liquids, streamline flow at low velocities, and turbulent flow

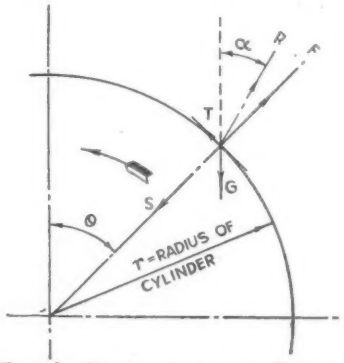

FIG. 2.—ILLUSTRATING THE FORCES ACTING UPON A ROTATING MOULD DURING CASTING.

at higher velocities. In liquid flowing at low velocities the particles take a steady path with the absence of eddy currents. Above a certain critical velocity the flow form becomes turbulent, and eddy currents are produced, resulting in an intimate mixing of the liquid. In turbulent flow the coefficient of friction between the liquid and the container increases rapidly with the velocity of flow.

The exact mechanism of flow in the centrifugal casting of metals is conjectural. It is possible that at the lowest rates of speed sufficient to maintain tube form, the liquid motion may tend to the streamline condition. At higher rates of speed, flow will undoubtedly tend to be turbulent. It is to be observed that at higher speeds in which turbulence is pronounced, mixing of the liquid will be more thorough. This will tend to counteract the tendency to separation of the constituents due to the centrifuging action induced by the extreme speed.

When the metal is once solid, the resulting tube rotates with the mould. This is substantiated by the fact that, when cold and shrinkage has occurred, considerable force is still required for extraction.

The graph in Fig. 1 gives a

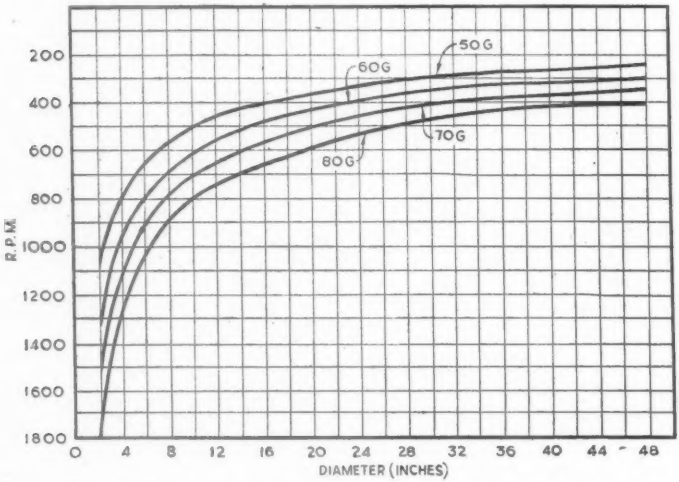

FIG. 1.—SPEED OF ROTATION IN RELATION TO THE INTERNAL DIAMETER OF THE MOULDS.

series of curves in which the speed of rotation is plotted against the internal diameter of the mould. The speeds are selected to provide approximately the value of G denoted on the particular curve, and it will be observed that the curves consist of right-angled hyperbolæ.

Resultant Force Acting on a Unit Particle in the Melt

For the purpose of explaining the structures encountered in centrifugal casting, it is necessary to calculate the forces acting on a crystal forming in the melt. Three forces may be considered to be acting on a particle of unit mass M. (*See* Fig. 2.)

The forces acting are:—(1) F—the centrifugal force due to the rotary motion of the particle; (2) G—the force due to gravity, and (3) T—the tangentially acting force causing the motion of the particle round the tube. The angular velocity of the particle is the same as that of the liquid. The angular velocity of the liquid depends on the friction between the liquid and the layout of already formed crystals.

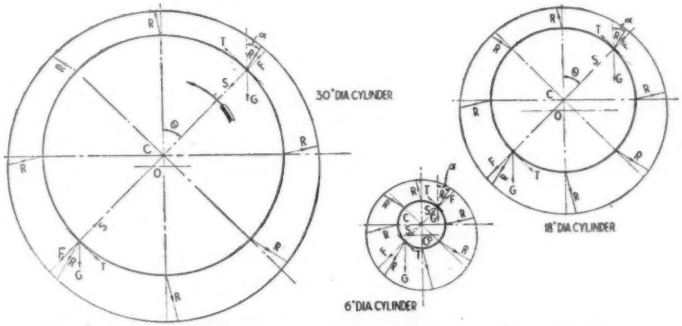

FIG. 3.—SHOWING VARIATION OF THE RESULTANT FORCE WITH VARIOUS SIZES OF MOULDS.

The following symbols are adopted :—

g = acceleration due to gravity. 32.2 ft./sec./sec.
r = radius of the cylinder in feet.
θ = angle of rotation at any position in radians.
α = angle the resultant makes with the vertical.
G = force due to gravity in lbs. weight.
F = centrifugal force in lbs. weight.
T = the tangentially acting force arising from the friction between the liquid and the mould in lbs. weight.
S = the reactionary force opposing F.
ω = angular velocity in radians.
μ = coefficient of friction between the liquid and mould.
R = resultant force required.

It is assumed that $F = x\,G$.

$$F = \frac{\omega^2 R}{g}$$

$S = F - \cos\theta$.

$T = \mu S$.

$T = \mu (F - \cos\theta)$

Then resolving the forces in the vertical direction

$R \cos\alpha = F \cos\theta - T \sin\theta - 1$.

Then resolving the forces in the horizontal direction

$R \sin\alpha = F \sin - T \cos\theta$.

$$R^2 = (F\cos\theta + T\sin\theta - 1)^2 + (F\sin\theta - T\cos\theta)^2$$
$$= F^2 + T^2 + 1 - 2(F\cos\theta + T\sin\theta)$$
$$= F^2 + 2(F - \cos\theta)^2 + 1 - 2F\cos\theta + \sin\theta$$
$$(F - \cos\theta) \text{ lbs. wt.}$$

$$\tan\alpha = \frac{F\sin\theta - \mu\cos\theta\,(F - \cos\theta)}{F\cos\theta + y\sin\theta\,(F - \cos\theta) - 1}$$
$$= \frac{F(\sin\theta - \mu\cos\theta) + \mu\cos^2\theta}{F(\cos\theta + y\sin\theta) - \mu\sin\theta\cos\theta - 1}$$

It may be, therefore, concluded that the variation in magnitude and direction of the resultant force R during rotation through an angle θ is conditioned entirely by the two factors, F and μ. The value of μ depends principally on the internal viscosity of the metal, the velocity, and the nature of the mould surface or deposited layer of crystals. Its evaluation in the case of metals is an extremely difficult accomplishment.

The value of the centrifugal force F depends entirely on the angular velocity of the metal and the radius. It has been shown, however, that in the case of thin cylinders of metal, a centrifugal force of about 55G (as calculated from the speed of the mould) is required to maintain complete tube form. It is considered that in the case of moulds rotating at a speed equivalent to 75G, the angular velocity of the molten metal is sufficient to develop a centrifugal force of from 2G to 4G on a crystal forming in the melt.

Variation of the Value of the Resultant During Rotation

The variation in the magnitude of the resultant force R has been plotted in the case of cylinders 30 in., 18 in. and 6 in. in diameter in Fig. 3. The principal feature is that the magnitude of the resultant is greater by a value of 2G at the basal position as compared with the vertex. This is of great importance in considering the development of the banded structures observed on macroetching. A circle may be circumscribed to touch the end points of the lines presenting the respective values of R. The centre of this circle is displaced vertically downwards by a value equal to G.

As the value of R is dependent only on F and μ, it is assumed that μ is a constant for one set of casting conditions; then if the three moulds are rotated at speeds equivalent to the value of 75G, the three diagrams are comparable. The only difference which is important in practice is that the complete reversals

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of direction of R varies as the speed. The value of the resultant force R is proportional to the density of the particle under consideration. The density of a crystal forming in a liquid metal is greater than the mother liquor for two reasons:—(*a*) The common metals are invariably more dense in the solid than in the liquid states; and (*b*) in the commercial alloys the primary crystals contain a greater proportion of the base element. As an example, in steel, the primary

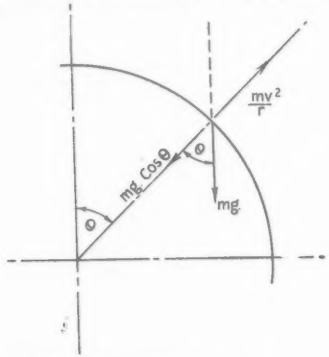

FIG. 4.—DIAGRAM SHOWING THE MECHANISM OF THE MOVEMENT OF A PARTICLE PLACED ON THE RIM OF A FLYWHEEL.

crystals contain a greater percentage of iron and less of the non-metallic elements, carbon, sulphur and phosphorus.

Immediately after formation the metallic crystals tend to be centrifuged outwardly. No attempt will be made to evaluate the exact velocity with which the crystals are centrifuged outwardly for a certain value of the resultant R. This velocity will largely depend on the viscosity of the liquid, and the size and shape of the crystals. It is of interest, however, to consider the case of a particle placed on the vertex position of a rotating flywheel, and to calculate the position at which the particle is flung from the rim, as in Fig. 4.

Suppose a particle of mass M is placed on the rim of a flywheel rotating with a peripheral speed of V ft./sec. Let θ be the angle of rotation at which the particle leaves the rim. The centrifugal force acting on the particle $= \frac{mv^2}{r}$ pdls. Resolving the force due to the weight of the particle along the radius $= mg \cos \theta$. The particle will leave the rim when $mg \cos \theta = \frac{mv^2}{r}$

$$\cos \theta = \frac{mv^2}{mgr}$$

$$\cos \theta = \frac{v^2}{gr}$$

That is, θ is proportional to the centrifugal force. Therefore, in the case of the three cylinders of 30 in., 18 in., and 6 in. rotating at a speed equivalent to a centrifugal force of 75G, it may be reasonably assumed that the metallic crystal forming in the melt tends to be centrifugal outward, after the same angle of rotation.

The primary conclusion to be drawn from the foregoing is that the force acting on a unit particle is not uniform, but is at a maximum at the vertex position and is gradually increased by a value of 2G at the lowest position. If the liquid metal was rotating at the same speed as the mould, the effect of superimposing a force of 2G on a force of 75G would be negligible. As it has been shown, however, that the metal rotates at a much lower speed, probably at a speed sufficient to develop a centrifugal force of 2G to 4G, the variations in resultant force assume important proportions, which will be discussed later.

Conditions of "Forced Vortex"

It is possible that under the conditions of "forced vortex" discussed, there is little or no variation in angular velocity at various positions of rotation, the momentum of the metal being sufficient to overcome local variations in force. At lower speeds in which the tube form is barely maintained, some "splashing" or disturbance of the metal is apparent at the vertex position. This factor indicates that the possibility of the existence of a variation of angular velocity merits consideration.

Any change in the velocity of the liquid at the higher rotational speed will become apparent as a

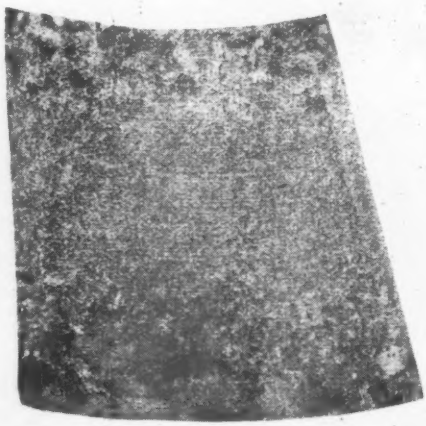

FIG. 5.—SECTION THROUGH CENTRIFUGALLY CAST GUNMETAL. × ⅓.

reduction in speed at or about the vertex position. This will tend to make the difference in the value of R at maximum position as compared with minimum position even more pronounced.

The complete mathematical evaluation of the problem has not been attempted, due to the lack of data on the value of μ and the general complexity of the problem. The fact that there is a minimum and maximum value of R is believed to have been reasonably substantiated. Further experimental work conducted on rotating cylinders, employing substances normally liquid at room temperature would prove very informative.

The above considerations apply only to a particle at the interface between the liquid and mould (or previously deposited crystals). As the statement has been made that the molten metal adopts the system described as a "forced vortex"; it, therefore, follows that the angular velocity of the liquid is a constant throughout, irrespective of the distance from the axis of rotation. A particle at the bore of the liquid is, however, acted upon by a lesser centrifugal force than a particle at the mould liquid interface, due to the decreased radius of the former, *i.e.*, centrifugal force $= \frac{w^2 r}{g}$

It, therefore, follows that, if a particle at some position near to the bore is centrifuged outwardly, then as the particle travels towards the periphery, the centrifugal force acting on the particle increases in direct proportion to the magnitude of the radius of rotation of the particle.

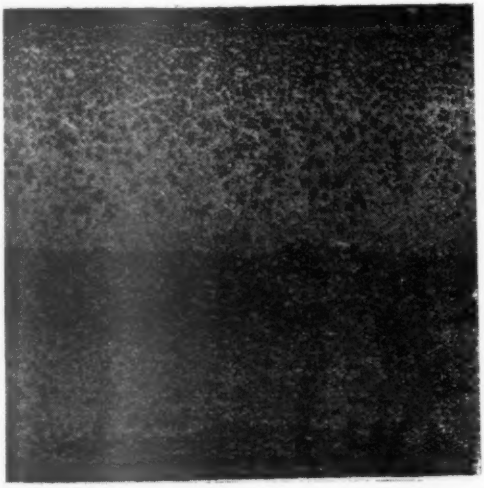

FIG. 6.—SHOWING BANDED STRUCTURE IN AN ALUMINIUM BRONZE. × 6 DIA.

Descriptions of the Structures Encountered in Centrifugal Castings

In Fig. 5 is shown a photograph of a section cut from a centrifugally cast tube of leaded gunmetal, 19 in. O.D. and 12 in. I.D., the speed of rotation being sufficient to promote a centrifugal force equivalent to 84G at the mould bore. This example was selected in view of the extreme wall thickness as offering the most extreme degree of separation. Other castings of smaller wall thickness and of varying diameters, however, have been found to present very similar features. The extent of the segregation across the face of the tube wall is shown in Table I. The general tendency is an increase in lead and tin towards the bore. At position (8) there is rather a pronounced increase in lead and tin contents, and this is confirmed by microscopical examination. There is some evidence of a smaller secondary peak at position (5), but this feature appears to be confined to thick-walled castings and has not been observed in castings of smaller section.

TABLE I.—*Analyses of Samples Taken with a ¾-in. Drill at Incremental Distances Across the Face of a Gunmetal Centrifugal Casting, 19 in. o.d. by 12 in. i.d.*

Position.		Sn	Pb	Zn	Cu	Ni
Outside	(1)	5.75	1.58	2.96	89.45	0.26
	(2)	5.86	1.75	2.99	89.15	0.25
	(3)	6.02	1.78	2.91	89.05	0.24
	(4)	6.13	1.89	3.25	88.50	0.23
	(5)	6.33	2.18	2.91	88.30	0.28
	(6)	5.68	1.78	2.33	89.05	0.26
	(7)	5.99	1.86	2.72	89.17	0.26
Bore	(8)	6.41	2.03	3.45	87.85	0.26

It will be observed in Fig. 5 that the crystal structure is gross in the areas adjacent to the bore and the periphery, and in the remainder of the section is uniformly fine grained. No counterpart of the banded structure observed in steel castings is apparent, and this may be regarded as typical of a large range of horizontal centrifugal castings of the bronze type.

In this class of alloys it may be assumed that segregation is not pronounced, but consists of a gradual increase of tin and lead content towards the bore, accompanied by a zone approximately ¼ in. wide, immediately adjacent to the bore, in which tin and lead, are noticeably higher than the remainder. In the freezing of the copper-tin constituent, the primary crystals are appreciably richer in copper, and have a less tin content than the mother liquor. In conformity with the procedure adopted in static castings, this is referred to as major segregation.

In Fig. 6 is shown a photomicrograph of a sample of aluminium-bronze of the following analysis:— Al, 8.9; Ni, 4.2; Fe, 3.9 per cent.; Cu balance. It will be observed that the structure is banded to an extreme degree. Examination of a full tube section showed the bands to be almost completely annular; there was, however, some tendency for adjacent bands to

The Formation of Banded Structures

join together in occasional positions. The external diameter of the casting was 7 in. and the internal diameter 5 in.

No attempt has been made to evaluate the extent of segregation across the bands by chemical methods. Examination of the microstructures indicates, however, that the bands are caused by a layer of almost pure α solid solution, disposed on the side of the band nearest

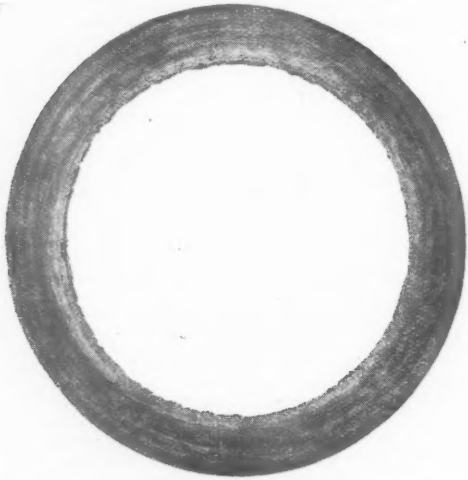

FIG. 7.—MACROSTRUCTURE OF A STEEL CASTING SHOWING BANDED STRUCTURE. × ½ (REDUCED).

the periphery. On travelling towards the bore, the proportion of β increases gradually, and finally terminates in a zone rich in β. The distance between the bands is 0.2 in., and the bands are repeated in identical fashion across the tube wall. No marked columnar zone was observed.

In Fig. 7 is shown a macroetching of a steel casting

TABLE II.—*Analysis of Drillings Taken with a ⅜-in. Drill at Positions Across the Face of a Carbon Steel Casting.*

Position.		C	Si	S	P	Mn
Outside	(1)	0.20	0.32	0.013	0.018	1.36
	(2)	0.21	0.31	0.013	0.017	1.38
	(3)	0.20	0.32	0.014	0.017	1.35
Bore	(4)	0.21	0.32	0.015	0.019	1.37
	(5)	0.28	0.35	0.022	0.027	1.45

18 in. O.D. and 15 in. I.D. The casting may be divided into three structural zones, an outer columnar zone, a highly banded middle zone, and an inner zone of relatively structureless nature. A sulphur print, which is not reproduced, showed some concentration of sulphur in the inner zone. The analytical variations across the section are shown in Table II. These results, which are typical of many similar investigations, indicate a reasonably constancy of composition across the tube wall, except for a marked increment of carbon, sulphur and phosphorus in the bore zone. This segregation is again referred to as major segregation, the highly banded zone is described as micro-segregation.

Consideration of the Formation of Banded Structures

The three samples described are considered typical of the range of alloys encountered in centrifugal castings, and all have been prepared under casting conditions and at speeds to give rise to the Type III structures described by Northcott and Dickin. A fourth type exists, that is the pure metal or homogeneous solid solution type. This has not been studied, but in view of the homogeneous nature of this type, no separation into the banded type of structure may be anticipated.

The three types of structure may be classified as follow:—

Tin-bronze Type

The example of leaded gunmetal shown in Fig. 5 is typical of the macrostructure of alloys possessing a long freezing range, when cast by the centrifugal process. This type of alloy embraces the cast iron, bronzes, and gunmetals, and is characterised by the absence of well-developed structures of the micro-banding type. Segregation takes the form of a gradual concentration of the constituent, which freezes last towards the bore; that is, in bronzes, there is an increase in α–δ eutectoid at this position.

The suggested mechanism of this process is as follows. When the copper-tin constituent freezes, the primary crystals to separate out are richer in copper and of less tin content than the mother liquor. Additionally they are of greater density, as the crystals contract to the extent of 4 to 6 per cent. on cooling. The centrifugal force acting on a particle is proportional to the mass of the body, and for this reason the first formed crystals are thrown outwardly, and tend to concentrate at the periphery. The mother liquor becomes progressively richer in tin, and on finally freezing deposits material considerably higher in tin content than the remainder.

This principle of centrifugal separation due to specific gravity is considered to be the basis of all segregation effects in centrifugal castings. A similar principle is widely applied in the centrifugal separation processes in commercial application. This explanation takes no account of the formation of micro-banded structures, but, as was previously pointed out, this type of structure is not of common occurrence in alloys possessing a wide freezing range. Very rarely a structure of this nature may be observed in

a bronze, but invariably the band is extremely ill-defined, and on microscopical examination shows little separation into the respective constituents. The absence of micro-banded structures in alloys of wide freezing range is considered to be due to the slow and progressive freezing experienced. No development of any marked columnar crystallisation has been observed in commercial centrifugal castings of bronzes.

Aluminium-bronze Type

Experience has shown that the formation of micro-banded structures is confined to those alloys possessing a narrow freezing range. Aluminium-bronze has the smallest *liquidus-solidus* range of any commercial alloy, and the most pronounced type of micro-banding is experienced. A factor tending to excessive banding in this material is the fact that the density of aluminium-bronze decreases rapidly as the aluminium content increases, as illustrated in Fig. 8. It is to be expected, therefore, that the primary crystals deposited from the melt are considerably denser than the remaining liquid. This effect is increased by the fact that contraction on changing from the liquid to the solid is substantial. The combination of these factors results in aluminium-bronze presenting examples of banding more intense than any other type of alloy examined. No marked columnar zone has been discovered in commercial centrifugal castings of aluminium-bronze.

The theory of centrifugal separation of two constituents of varying chemical composition serves to explain the concentration of the primary freezing constituent to the periphery, but throws no light on the periodicity of banding encountered in centrifugal castings of alloys possessing a narrow freezing range.

Steel Type

The steel centrifugal casting shown in Fig. 7 differs from the previous two examples in possessing three entirely distinct structural zones. It is proposed, therefore, to consider each zone in turn.

Columnar Zone

The columnar zone in steel centrifugal castings presents entirely similar features to the corresponding zone in static castings, and it was shown in the Paper by Northcott that the conditions for propagation are identical. The columnar, or Type II, structure is favoured by conditions promoting a steep temperature gradient, that is to say, a mould of high conductivity, a high casting temperature, and a slow rate of pour. It will be observed that in the example shown in Fig. 7 no banding of the columnar zone is observed. This is confirmed in the literature, and no single instance of banding in a columnar structure has come to the notice of the Author.

The columnar dendrites are adjacent to the outer surface of the casting, but differ from similar structures in static castings in that they are frequently inclined to the normal. As was discussed in a recent Paper,[4] this indicates that relative movement was occurring between the liquid and solid phases during solidification. This definitely suggests that the angular velocity of the liquid is considerably less than the angular velocity of the previously deposited crystals.

Steep Temperature Gradient

It is generally accepted in static ingot practice that a steep temperature gradient is essential to the formation of columnar structures. The extreme turbulence encountered in centrifugal casting will tend to upset the development of these conditions by thoroughly mixing the liquid melt. It is, therefore, to be expected that in centrifugal castings the extent of the columnar zone is restricted as compared with

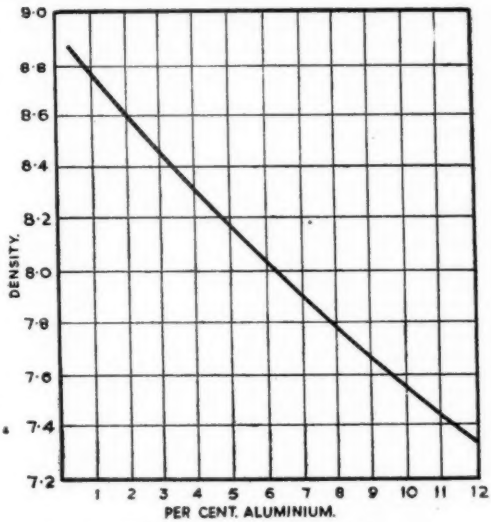

FIG. 8.—DENSITY OF COPPER-ALUMINIUM ALLOYS.

static castings. This is substantiated in practice and examination of Fig. 7 will reveal the small extent of this zone. There is reason for believing that the formation of columnar crystals is restricted to the teeming period, when a steep temperature gradient may be set up. Immediately pouring ceases the effect of turbulence, by intimately mixing the liquid melt, is to inhibit this type of crystalline growth.

It may, therefore, be concluded that columnar crystals in centrifugal casting are developed adjacent to the mould wall by steady uninterrupted growth in a similar fashion to static castings. There is no possibility of periodic structures in this zone unless further factors are introduced. This may happen in castings run at slow speeds in which all the metal is not maintained in tube form. In this instance as solidification proceeds further metal is "picked up," resulting in a disturbance of the structural formation as found in Type I castings.

The Formation of Banded Structures

Non-columnar Zone

In static castings the change-over from columnar to equiaxed formation occurs when the temperature gradient has evened out, and crystal growth proceeds with equal facility in all directions. Any feature of the nature of banding is unknown, and must be considered to be entirely a function of the rotation. The first crystals to commence freezing in steel are purer than the mother liquor, and tend to be low in carbon, phosphorus, and sulphur. These crystals are of higher specific gravity than the mother liquor because of their comparative freedom from the lighter non-metallic elements, and to the fact that in metals the solid phase is invariably denser than the liquid. These heavier crystals tend to be centrifuged outwardly, and on the examination of banded structures these primary crystals invariably occupy the outside position. The first supposition would be that segregation would take the form of a gradual concentration of the later freezing material to the bore, as is apparent in bronzes and other alloys possessing a long freezing range. It is submitted that the periodicity resulting in micro-banding is due to the extremely rapid rate of freezing and deposition that occurs in alloys exhibiting a narrow freezing range.

As was discussed in the mathematical treatment of centrifugal casting, the force acting upon the liquid (or crystal forming in the liquid) is not uniform during rotation. The resultant force is greater by a value equal to 2G at the bottom position as compared with the vertex. This difference may be accentuated if there is any retardation in angular velocity at or about the vertex position.

If it is assumed that the angular velocity of the metal is such as to produce a centrifugal force not greatly exceeding 1G at the vertex position (possibly 2G to 4G), then the effect of the variation in force during rotation is important. The theory is advanced that the centrifugal force in the upper part of the casting is not sufficient to promote a degree of separation detectable on etching. As the liquid rotates from the vertex position the centrifuging action is increased, and separation of the primarily freezing constituents is effected, and results in the formation of a micro-band during rotation in the lower arc. As the liquid ascends the centrifuging action diminishes and segregation ceases, and a uniform structure is deposited. It follows from this hypothesis that one band is deposited per revolution, and examination of Fig. 1 will show that this theory is not untenable.

The number of bands in this casting is approximately 15, and the mould was rotating at a speed of 9 revolutions per sec. The speed of rotation of the liquid metal is conjectural, but if it is assumed that the metal is rotating at a speed of three revolutions per sec., it follows that the rate of freezing of the equiaxed zone is $\frac{15}{3} = 5$ sec.

Minimum Time

This period is approximate and cannot easily be substantiated. It is considered, however, that this is the minimum time in which the zone may freeze. The thickness of the equiaxed zone is 1.75 in. Even this rate of freezing is far in excess of what has usually been considered the normal rate of freezing of steel. It will be shown, however, that marked supercooling occurs in steel centrifugal castings, and it is not unreasonable to suppose that in a supercooled liquid when once crystallisation is initiated freezing may occur with extreme rapidity. This is illustrated by the experiment of introducing a crystal into a supersaturated solution of sodium sulphate.

This is illustrated in the freezing curve of a steel centrifugal casting in Fig. 9. The observations were taken by an optical pyrometer sighted on a point 1 ft. from the pouring end. As almost perfect black body conditions were present, accurate results could be expected. Observations were commenced immediately the pouring box was removed, when the temperature was 1,530 deg. C. This temperature decreased rather rapidly to 1,480 deg. C. in 6 min. From this point the temperature remained perfectly constant for 6 min., indicating that supercooling was in operation. There

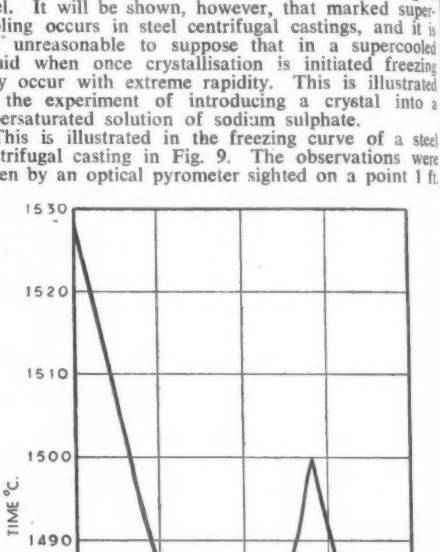

FIG. 9.

was then an immediate jump to 1,500 deg. C., at which point solidification was presumed to occur. The temperature then fell steadily in the normal fashion. This curve is typical of similar readings taken on upwards of 50 steel castings. The experiment of stopping the machine at certain definite periods confirms that solidification is rapid and at the point indicated. These observations indicate that solidification in the equiaxed zone of centrifugal castings may be considered to take place in an extremely rapid fashion.

It is not suggested that solidification in the equiaxed zone of static ingots and castings is identical with the procedure described above. The conditions are somewhat different: the factors in centrifugal casting tending to promote a uniform supercooling of the liquid are presence of excessive turbulence, small wall thickness, and absence of gas pressure.

Bore Zone

The bore zone is usually found to occupy the section of the tube immediately adjacent to the bore. Analysis shows that this zone is noticeably higher in carbon, sulphur, and phosphorus, and corresponds to the discarded head in static ingots. The two conflicting theories of differential freezing and two conjugate liquid solutions may be advanced to explain the formation of this zone. It is not proposed to discuss the merits of the two respective theories, except to suggest that the application of controlled centrifugal separation is a possible method of isolating and confirming the existence of a carbon, sulphur, phosphorus rich complex in molten steel.

Conclusions

This Paper has not been written as the accumulated results of a definite research programme, as the castings examined have been encountered in normal commercial practice. In view of the growing interest in this subject, however, it was thought that the time was opportune for the presentation of what might be described as a "working theory." The examples, although few in number, have been carefully selected as being typical of a wide range of alloys. It is hoped that research on more orthodox lines may be stimulated, which may to some extent modify the conclusions drawn in this Paper. It is considered, however, that the following points have been substantiated in a reasonable fashion.

(1) Heterogeneity effects in centrifugal casting may be denoted by the terms major and minor segregation, in conformity with previous practice.

(2) Segregation effects are due to the centrifugal separation of purer crystals more dense than the melt, in the direction of the periphery.

(3) The tendency to the formation of micro-banded structures bears a relationship to the magnitude of the freezing range of the particular alloy.

(4) The columnar zone in centrifugal castings is always free from micro-banding, and is similar in essential features to the corresponding area in static castings.

(5) Micro-banding is confined to the non-columnar zone, and the bands are laid down in successive layers. There is no evidence of freezing from disconnected nuclei.

(6) The liquid metal may be considered to have a considerably reduced velocity as compared to the mould.

(7) The resultant force acting on a particle in the liquid is known to vary between a maximum and a minimum during rotation to a degree sufficient to promote the formation of one band per revolution.

The Author wishes to express his sincere thanks to the many friends who have assisted in the preparation of this Paper, and for the facilities afforded, without which the Paper could not have been written.

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SILICA GEL

Silica gel as it is made now is really not a gel, states R. G. SKERRETT, writing in "Compressed Air Magazine." Instead, it is a rugged material that is nearly as hard as window glass, and can be had in any screen sizes desired—the individual granules being as clear as crystal quartz. It is produced from a soluble silicate such as the familiar water glass that has long had various commonplace uses. Silica gel is an insoluble material possessing many remarkable qualities, including extreme porosity. The granular sizes of the material vary widely. The 3- to 8-mesh and 6- to 16-mesh silica gel is used in the separation of vapours from gas mixtures; the 14- to 20-mesh for the dehydration of liquids such as refrigerants; 42-mesh for static adsorption, such as in the prevention of corrosion, mildew, and mould in closed spaces; while 28- to 200-mesh plays its part in the purification of liquids, such as the refining of mineral oils. The coarser grades also serve as carriers for active metallic catalysts in many chemical processes. Silica gel has an important field of application in air-conditioning.

INDUCTION-HARDENED STEEL

Metallurgical characteristics of induction-hardened steel were discussed by JAMES W. POYNTER at a Pittsburgh meeting of the American Society for Metals. The author stated that samples of SAE 4340 steel (C 0.35 to 0.40; Mn 0.60 to 0.80; P 0.040 max.; S 0.040 max.; Si 0.20 to 0.35; Ni 1.65 to 2.00; Cr 0.70 to 0.90; Mo 0.20 to 0.30) subjected to high-frequency heating and quenched have the same characteristics as test-pieces quenched after furnace heating. Longer heating periods at reduced power input lead to deeper hardening, while specimens containing small particles of carbide respond more readily to heat-treatment than those with larger carbide particles. The author suggested that the effect of frequency on depth of hardening had been exaggerated; the rate of heat flow, however, has a definite effect on depth of hardness.

NOTES FROM THE BRANCHES

LONDON BRANCH.—A party of members of the branch visited Ealing Park Foundry on February 6, but unfortunately many applications could not be accepted, as the number was limited to 50. MR. R. B. TEMPLETON gave a brief review of the policy of the company and the main types of castings produced, and laid stress on the importance of the maximum production per unit area of floor space in a works where no room is available for further expansion. He also spoke of the high average age of the craftsmen and the necessity of the recruitment of apprentices to make good the inevitable loss of these men in the near future.

The party then made a tour of the works, where the attention given to maximum utilisation of available floor space was evident. In the bench shop, the raised platforms for the alignment of moulds under the monorail for pouring helps orderliness and neatness. In the main hand-moulding shop the planned layout of boxes for moulding and casting is in marked contrast to the haphazard arrangement in the majority of jobbing shops and is a considerable factor in the maximum usefulness of the floor space. Here there was a wide range of crankshafts, which form an increasing proportion of the output. Machine-tool castings, gears, press tools, pumps, and hydraulic gear form the bulk of the other work in progress, most of it made in the higher strength grades of "Meehanite." All moulds in this department are dried in two stoves heated by C.R.A. thermostatically controlled furnaces. The shop is served by two overhead cranes of three and five tons capacity, augmented by jib cranes for moulding and for metal handling at the cupolas in the centre of the shop. Melting is under constant supervision and control is aided by blast-volume and pressure recorders, and the sampling of each ladle of the treated metal attracted considerable attention.

The same furnaces serve the adjacent machine-moulding bay. Here pneumatic moulding machines of the plain jolt—pattern draw type of the firm's own design—are grouped around sand bins in line down the centre of the shop and moulds are placed on a gravity conveyor for casting from ladles suspended on monorails. After casting the moulds are hand-traversed to a central knockout. From this point the boxes are returned to the machines by gravity conveyor under the sand bins, and after treatment in a plant incorporating an August mill, the sand is delivered to the bins by a large overhead skip centrally controlled by the sand-mill operator. The whole layout involves a minimum of capital expenditure and power consumption and yet achieves the major advantages of complete mechanisation and also retains flexibility. The current production is 600 moulds per day, and predominant amongst the castings being made were refrigerator parts, some of them for export.

The coreshop employs girls on repetition work, and the work benches are placed adjacent to a steel band conveyor serving a continuous drying stove. For the cleaning of small castings the fettling shop has a rumbling barrel, a Stormblast continuous barrel, and a table shot blast. Every effort is made to reduce hand work to a minimum, and full use is made of grinding equipment, including cutting-off wheel, stand grinders, swing arm machines, and Hi-cycle portable machines, all of modern high-speed type. From the fettling shop small castings pass on a gravity conveyor through inspection to the despatch department, where the castings collected for delivery drew commendation for excellence of surface finish and appearance.

The laboratory was recently equipped to provide the maximum of control of the high-duty iron, and the equipment demonstrated included Vickers projection microscope, and Avery fatigue, hardness and tensile machines. Tensile tests on "Meehanite"—"G.M."—as used for crankshafts, gave convincing evidence to the visitors of the high-strength characteristics of this material. The development of the use of "Meehanite" for crankshafts was illustrated by a collection of cast shafts, ranging in size from small refrigerator compressor shafts to Diesels 7 ft. in length. After tea in the works canteen, a vote of thanks was proposed on behalf of the visitors by Mr. G. R. Webster and seconded by Mr. G. C. Pierce.

DEATH OF MR. W. E. CLEMENT

Mr. W. E. Clement, C.B.E., managing director of Thomas & Clement, Limited, Morfa Engineering Works, New Dock, Llanelly, died on February 17, at the age of 69. Mr. Clement was well known in foundry circles throughout the country and had been a leading personality in the industrial, social and political life of Llanelly for more than a generation. In addition to his life-long association with Thomas & Clement, he was a director of the Glanmor Foundry Company, Limited, and vice-chairman of the Glanmorfa Foundry & Engineering Company, Limited.

He was Chairman of the Welsh Engineers and Founders Association and of the Welsh Engineers and Founders Conciliation Board for 14 years, and added to his already great responsibilities during wartime by accepting the vice-chairmanship of the Welsh Regional Board of the Ministry of Production, and membership of the Minister of Production's National Advisory Council. For his work in this connection he was awarded the C.B.E. in January, 1942. Up to 20 years ago, Mr. Clement was an active member of the Llanelly Borough Council. His varied responsibilities in succeeding years included those of Commissioner of Inland Revenue and chairmanships of the Board of Governors of the County School and the Hospital Committee. He was keenly interested in bowls, rugby football and cricket, being an ex-president of the Welsh Sporting Association.

BOOK REVIEW

Palmer's "Company Guide" (35th Edition). By J. Charlesworth, LL.D. Published by Stevens & Sons, Limited, 119 and 120, Chancery Lane, London, W.C.2. (Price 5s. net.)

It is obvious that any book which reaches its 35th edition must be regarded as either a classic or a standard work. Entering into the latter category, this book, after thorough and constant revision, well retains its popularity with company secretaries and the like as a reliable work of reference on legal and practical questions arising in connection with company law.

V. C. F.

PRESSURE DIE CASTING*

By G. T. VICARY

Whilst the pressure die-casting process probably lies more in the domain of the engineer than does sand casting, the fact remains that it has the same basic objective as that of the foundryman, namely, to fill a mould completely with molten metal, producing a dense solid casting of a predetermined size, with physical properties of a predetermined order. Like the casting of molten metals in sand, pressure die casting is more of an art than a science, and the actual casting problems encountered are very similar to those in foundry work. Pressure die castings are apt to have internal unsoundness, for instance, to have "sinks" occurring, and to have poor surface appearance, unless skill and forethought are applied in the design of the dies.

Zinc Alloy Die Castings

The process of pressure die casting has made very rapid progress in the last 20 years. The increase in the manufacture of pressure die castings has been primarily due to the evolution of the 4 per cent. aluminium high purity zinc alloys, possessing very high strength, good dimensional stability, and the ability to maintain these properties under service conditions. The development of these alloys, which are covered in Great Britain by British Standard Specification 1004, focussed attention on die-casting machines and die design in general, which resulted in improvements in the die casting of all alloys. The tonnage of zinc alloy die castings both here and in America, however, is greater than the total of die castings in aluminium, brass, tin and lead alloys.

The majority of machines used to-day are power-operated; very low-pressure machines such as hand-operated or direct-air machines are not now used to any great extent. High-pressure machines fall into two main types, "cold-chamber" machines in which the metal for each shot is hand-ladled into the pressure cylinder, and gooseneck machines in which the metal automatically flows into the pressure cylinder, which is kept submerged in molten metal. Either hydraulic or pneumatic operation is used to operate both types of machine. "Cold-chamber" machines are used mainly for aluminium and brass die casting, while the gooseneck type is used for zinc and other alloys of lower melting point. Modern high-pressure machines are now casting parts as large as 36 in. by 9 in. by 8 in. and as small as zipp fastener components. The capacity of the British die-casting industry is stated to be some 25 million castings per week in zinc alloy alone.

Pressure die castings are produced in precision-made steel moulds or dies containing one or more impressions of the article required. The die opens primarily into two parts to allow for ejection of the casting, but the die blocks may be further divided by means of slides and cores to produce holes, or irregular-shaped openings at various angles in the castings. The die is fitted on the die-casting machine, which performs the operation of opening and closing the die and injecting the molten metal under pressures of 1,000 to 10,000 lb. per sq. in. or more. The casting solidifies almost instantaneously, and the machine is operated to open the die and eject the casting, the cycle being then repeated. The number of times a machine can be operated in an hour depends on several factors, but 250 shots per hr. for an 8-oz. casting is an average rate of production.

The majority of castings only require simple trimming operations to be ready for use. Under favourable conditions, castings in zinc alloy can be made accurately to 0.001 in., while parts with a maximum number of 24 internal and external threads per in., and holes as small as 0.031 in. dia. are being successfully cast. These limits are greater for aluminium or copper alloys. The die life for the low melting alloys of zinc, tin and lead is almost indefinite, but decreases rapidly as the melting point of the alloy increases.

Early History

The pressure die-casting process is quite the youngest branch of metal casting. Gravity die casting, if a stone mould can be termed a die, dates back to the Bronze Age, but the first pressure die-casting machine was patented by Sturgiss in 1849. This was a machine for producing type in tin base alloys, and although it is probable that type-casting machines were invented a few years before this, Sturgiss' machine is generally recognised as the parent of modern die-casting machines.

The first machine for making miscellaneous castings followed some 20 years later, and it is interesting to note how the development of alloys for pressure die casting was greatly affected by the type metal alloys for which these machines were originally invented. This influence will be traced later. These early machines were all hand-operated, and it was not until 1907 that the first machine utilising compressed air for the injection of the molten metal appeared. This was the forerunner of the "direct-air" type of machine, which is still used but not to a great extent.

In this type of machine, compressed air at a pressure up to 500 lb. per sq. in. is allowed to act directly on the molten metal situated in a "gooseneck," thus forcing it into the die cavity. The ultimate development of this type of machine is the fully automatic Madison Kipp, in which all operations are carried out mechanically by means of copes. Recently the Author has seen three of these machines in operation, but although they are only about 10 or 12 years old, no new machines, so far as the Author is aware, of this type are now being installed locally. This Madison Kipp machine is very interesting, however, since the fully automatic cycle of casting operations is rare in pressure die casting. The operation is by

*A Paper read before the Bristol and West of England branch of the Institute of British Foundrymen.

Pressure Die Casting

electric motor drive, and the cams perform the operations of opening and closing the dies in a predetermined time cycle, with the air pressure being supplied to the goosenecks at the same instant during the cycle. All the operator does is to keep the machine supplied with metal, and to be ready to stop it, if a casting jams, or some other mishap occurs.

The machines shown in the film [displayed at the conclusion of the lecture] are mostly of the gooseneck air-operated plunger type. The Schultz machine on which the die-casting operations are shown in the earlier part of the film, is a very good example of this type. In this particular machine the die opening and closing operations are performed hydraulically. As the molten alloy must of necessity come into contact with so many ferrous parts in machines of this type, they are only suitable for use with alloys which do not attack steel, *i.e.*, tin, lead, and zinc alloys.

The machines used for casting aluminium or copper alloys are of the type termed "cold-chamber" machines. The injection pressures available on these machines are much greater than on the submerged plunger type. Using a line pressure of 100 lb. per sq. in., on the Schultz machine it is possible to obtain metal pressures of up to 3,500 lb. per sq. in., but on hydraulically operated "cold-chamber" machines, the metal injection pressure can be as high as 20 tons per sq. in. In the "cold-chamber" type of machine in which the metal for each slot is melted in a separate furnace, and hand-ladled into an orifice in front of the plunger, it can be realised that molten metal is only in contact with the steel parts of the machine for a fraction of a second.

The Metal Die

The most important part of the pressure die-casting process is the die. Die life for the low melting point alloys such as zinc, tin and lead is almost indefinite, but it decreases rapidly with increase in melting point of the alloy used—when it is realised that the speed of the molten metal entering a die is of the order of 40 m.p.h., and in the case of aluminium and brass alloys the metal is red-hot, some idea of the arduous duty expected from die steels can be visualised. There is, therefore, considerable eroding action caused by the molten metal, and in addition to the actual mechanical shock produced by the impact of the alloy upon the die cavities and cores, the thermal shock caused by the molten metal on the surface of the die is heavy, particularly with the higher melting point alloys.

TABLE I.—*Typical Alloys for Die Casting.*

Zinc Alloys	Al Per cent.	Cu Per cent.	Mg Per cent.	Zn (99.99) Per cent.	Tensile Strength. Tons per sq. in.	M.P. Deg. C.
B.S.S. 1004/A	3.9–4.3	0.03	0.03–0.06	Balance	18.6	381
B.S.S. 1004/B	3.9–4.3	0.75–1.25	0.03–0.06	Balance	21.2	381
Aluminium Alloys	Si Per cent.	Cu Per cent.	Fe Per cent.	Mn Per cent.	Al Per cent.		
L.33	10–13	0.1	0.6	0.5	Balance	15.5	565
D.T.D. 424	3–6	2–4	0.8	0.7	Balance	16.5	618
Lead Alloys	Sb Per cent.	Cu Per cent.	Sn Per cent.	Pb Per cent.			
	15.0	1.0	4.0	Balance	6.2	255
Tin Alloys	Sb Per cent..	Cu Per cent.	Sn Per cent.			
	4–5	4–5	Balance		4.0	204
Magnesium Alloys	Al Per cent.	Zn Per cent.	Mg Per cent.			
	9.0	0.5	Balance		14.8	604
Copper Alloys	Zn Per cent.	Si Per cent.	Cu Per cent.			
	34.0	1.0	Balance		29.1	857

Die Costs

There is considerable room for improvement in available types of die steels to resist thermal shock. In fact, the development of the process of pressure die-casting brass is only hampered by this fact. Machines are available, but the life of dies, even if made in high alloy steels, is quite short, and in most cases, the process is uneconomic. When it is realised that a die may cost £200 to £300 it must be agreed that a considerable number of castings are required from it

to bring the die cost per casting down to an economic level. As may well be expected, the die cost per casting is one of the most important factors in the cost of a die casting, and at the outset, therefore, the process can only be considered where 5,000 or more castings are required. In some cases, the accuracy of the castings made is such that no machining is required before they go into use.

Surface of Die Castings

Owing to the fact that the die cavity is highly polished to withstand the high pressure at which the molten metal fills the die cavity, and to the character of the die-casting alloys themselves, the resultant casting is a very accurate reproduction of the die cavity. It has a good smooth surface finish and the amount of machining required to produce a finished component is at a minimum. All castings, however, require trimming, that is, the removal of the flash which occurs at parting lines of the die assembly, and the gates and runners where the metal enters the die cavity. In gating a casting, one of the objects is to use as thin a gate as possible in order to facilitate the removal of the runner by hand.

So accurate is the reproduction of the die cavity, that fine lettering or ornamentation may be readily produced on the surface of casting, requiring no further treatment unless plating or enamelling is specified. With zinc alloy die castings, at any rate, the surface finish is such that only a light buffing operation is needed to prepare a lustrous surface ready for plating. In addition to the production of accurate cast threads, inserts of various materials may be placed in the die, and the casting formed around them fixing the inserts in position with very great accuracy.

The casting speed on modern machines naturally varies with the size and complexity of the casting, number of cores to be withdrawn, length of time taken for the casting to solidify and so on. A modern plunger-type machine using zinc alloys, for instance, and making a fairly single 8-oz. casting is readily capable of production at a rate of 250 shots per hr. (the act of forcing the molten metal into the die is termed a shot). When it is realised that a casting of this size could be made in a multi-impression die, containing four or more impressions, with an output of some 1,000 castings per hr., the potentialities of the die-casting process can be clearly visualised.

Cost of Die Castings

Pressure die castings are, of course, fairly expensive, and even in zinc alloy (the lowest price alloy, and incidentally the strongest) a figure of 1s. to 1s. 4d. per lb. for medium-sized castings taken in quantities of 10,000 is usually charged. The cost of the die is in addition to this. Pressure die castings are not sold by weight, but at so much per 100, the price falling the larger the number taken. In general, pressure die castings cannot compete with cast-iron castings. In exceptional cases, however, such as that of a petrol can screw cap, a million of which were required, a pressure die casting in zinc alloy proved to be cheaper than the cast-iron product. Owing to the quantities involved, a die containing 10 impressions could be used, the threads being cast in. A mechanical device was used to unscrew the cores forming the threads. The price of die castings in aluminium alloy are slightly higher per 100 than for zinc alloy, and, of course, owing to the special alloy steels required for the dies, die costs are slightly higher also.

Requirements of Pressure Die-casting Alloy

A good alloy must possess certain distinct characteristics. It must not attack iron and steel, at any rate if used for plunger-operated gooseneck machines. In "cold-chamber" machines the molten metal is only in contact with the steel portions of the machine for a fraction of a second, and therefore this factor is not quite so important. In the early days, however, "cold-chamber" machines were not available. In most alloys, too, attack on the steel parts of the machine would be accompanied by solution of iron in the alloy, causing sluggish flowing metal and brittle castings. The die life is inversely proportional to the melting point of the alloy, and therefore a low melting point is to be desired to give long die life. As can be imagined, when the molten alloy fills the die impression, a rapid rise in temperature occurs on the die face. This is followed by a just as rapid temperature fall, as the heat flows away from the casting into the interior of the die blocks. This leads in time to "heat-checking," *i.e.*, fine cracks on the surface of the die, which are, of course, reproduced in the casting, thus marring the fine surface finish which is a feature of pressure die castings. The importance of the melting point of the alloy can therefore clearly be appreciated.

Another important attribute of a good die-casting alloy is what might be called for want of a better term "castability." This attribute could be defined as "sufficient fluidity at the temperature of casting to fill the die impression completely, giving a casting possessing accuracy of dimensions, reproduction of fine detail, and smooth surface finish." Probably one of the most important factors in "castability" is the viscosity of the molten alloy; this property is greatly affected by the alloy constituents—even the minor additions. A good alloy should possess such castability that even a scriber mark on the die surface should be reproduced on the solid casting. The resultant pressure die casting should, of course, possess good mechanical properties, be free from porosity in stressed sections, and have a smooth and pleasing appearance. In some cases, the castings should be capable of taking a good plated or enamelled finish.

In the gradual evolution of alloys possessing these desirable attributes, it is interesting to trace the influence of the die-casting machine's early history. The art of pressure die casting developed from type casting, and the first alloys used were therefore based on tin, with additions of lead and antimony. It was soon found that alloys used were therefore based on tin, with additions of lead and antimony. It was also soon found that alloys based on zinc had low melting points and produced stronger, and, of course, cheaper castings.

Pressure Die Casting

The addition of tin to the zinc to produce a freely flowing molten alloy followed naturally. It was found that these zinc/tin alloys, usually containing about 6 per cent. of tin, attacked the steel and iron parts of the die-casting machine, and small amounts of aluminium were added to prevent this occurrence. The discovery was then made that a higher aluminium content further increased the fluidity of the molten alloy, and incidentally further improved the mechanical properties of the castings. It is not surprising that alloys of this type in which aluminium largely replaced the expensive tin addition began to find extensive use in industry.

In those days most die casters made their own alloys, and the practice of adding tin to "sweeten" the alloy was very prevalent. Large amounts of castings made in these zinc aluminium alloys containing tin and probably lead, in substantial proportions, went into service, and the results were disastrous, since after being in service for some time the castings were found to distort, increase in size, become very brittle and in some cases disintegrate altogether. The repercussions of this period are still felt even to-day.

The discovery of Brauer and Peirce in 1922, that these failures were the result of intercrystalline corrosion caused by tin, lead and cadmium led to large amounts of research work which resulted in the formulation of stable zinc alloys such as are typified by alloys to British Standard 1004, Mazak being a typical commercial product corresponding to this Specification.

The use of zinc die castings became so successful, that a great fillip was given to the manufacture of die-casting machines. The advent of the "cold-chamber" machine in its improved form rendered possible the commercial casting of light alloys such as L33, LAC112, DTD424, etc., with good mechanical properties. It is expected that considerable increase in the size of the pressure die-casting industry will take place, particularly since the widespread use of pressure die castings with their enormous production potential relieved numerous machining bottlenecks during the critical stages of the war, thus showing what the industry was capable of producing.

The film [which followed] deals mainly with the history of the development of zinc alloys, and most of the casting operations shown are in zinc alloy. Incidentally it will be noted that the term "die casting" used in the film denotes pressure die casting. In America, gravity die casting is termed "permanent mould casting," but in England the term "die casting" alone implies the gravity process.

THE PRESTON WORKS of the English Electric Company, Limited, are to build 32 electric carriages for the suburban services of Bombay, states the India Office. Work on the contract will start at once and delivery is expected to be complete early in 1948. The contract may be increased to 64 vehicles.

HEAVY CASTINGS OF A CENTURY AGO

By T. R. HARRIS

During the 'forties of the last century some very large pumping engines were built in Cornwall necessitating heavy castings. When James Watt introduced his engine into the mines of Cornwall in 1777 he had to get his castings from Bersham. In 1778, when requiring a 63-in. cylinder cover in a hurry for an engine then being erected at Chaceswater, near Truro, a furnace was erected on the mine for the purpose of casting this cover. The results were not encouraging, as it was not until the third attempt that a casting was made which Watt thought would serve as a shift until a better one could be got from Bersham.

By the 'forties, Cornish founders were making large, heavy castings successfully. In June, 1844, it was reported that a large cylinder case was lately cast at the Hayle Foundry "which measured 106 in. in diameter, and upwards of 14 tons were melted for the occasion, and the whole mass of liquid fire ran into the mould in a time almost incredible. It has proved an excellent article and is the largest ever cast for mining purposes and reflects great credit on the manufacturers."

In April, 1847, an account stated: "The enormous piston cap for the engine contracted for by the Perran Foundry Company with the Dutch Government for draining the Haarlem Lake was cast at Perran on Friday, the 26th ult., weighing nearly 24 tons, being the heaviest piece of casting belonging to the engine." The same account mentioned that the Perran Foundry Company had at that time in course of construction engines for "Staffordshire, Scotland, Holland, Mexico and Australia."

Perran foundry, like its own illustrious contemporary, Hayle foundry, has been closed for many years, but there are still examples of its work in existence, some of which the Cornish Engine Preservation Society hopes to secure as a memorial to Cornish engineers and founders of a bye-gone day.

Another note in April, 1847, records: "On Friday a 144-in. cylinder for the Haarlem Lake, Holland, was cast at Messrs. Harvey & Company's foundry. There were 36 tons of iron melted for the occasion, and near 30 tons of that mass of liquid fire ran into the mould in one minute and a half. The remainder was used for some other articles for the engine."

IRON AND STEEL OUTPUT

Pig-iron and steel production in January, 1946, with figures for January, 1945, for comparison, is given below:—

	Pig-iron		Steel ingots and castings	
	Weekly average	Annual rate	Weekly average	Annual rate
	Tons	Tons	Tons	Tons
January, 1945 ..	127,100	6,610,000	216,300	11,245,000
Total, 1945	136,700	7,107,000	227,300	11,821,000
January, 1946 ..	143,600	7,465,000	228,600	11,887,000

LOAM WORK

By S. F. WATSON

The art of loam moulding, which has declined in recent years, is being lost to the younger members of the trade. The use of loam moulding in foundries saves labour and material, and on various jobs also saves time. It is essential that the art of loam moulding should be retained and practised more by the trade.

It is proposed to give examples of three types of jobs for which loam moulding is the most suitable method. It will be seen that in some respects it has been possible to improve upon the usual methods in general practice. The first example (Fig. 1) is an amalgam barrel, and the way the moulders used to make it was to put the bottom plate down, put on the cross, put in a spindle, and then sweep up the bottom bed with a strickleboard. The job was then put in the stove for the night. The following morning it was blackened.

Before putting the building ring on, a slight layer of loam was placed on the bottom. In many cases, however, it was found that when the mould was lifted off, loam remained at the bottom, so that the joint was practically destroyed. To overcome this difficulty, when the beard was fitted in, blocks 2 in. square were placed at four different places in the joint, then the moulder built up the bottom plate with bricks in order to get the air away. After this was finished the loose pieces in the strickleboard were removed. In other words, a dummy flange was made. One could then start to build right up to the top on the same board and on the same day. The cope was removed that day, so that at the same time the moulder could start building up the core; *i.e.*, both the cope and the core went into the stove on the same night. Next day the job was blackened and was ready to cast the following day.

In the second example (Fig. 2) a dummy pattern was first swept up, or in other words the whole of the core inside was swept with the metal thickness on, the brickwork being then completed up to level with the flange. Provision was made to cast the runners on the bottom of the flange by placing a cake core over the runners and building up the runners in the cope. In building up the job two drawbacks were removed. Then the whole body was taken off the cope and placed on one side. The strickleboard was put on again and the thickness of metal taken off the core. A template was used to set up the two branches.

In the third job (Fig. 3) the core had to be made first and was lifted out, the spindle and strickleboard being then replaced. After getting level with the bottom joint the moulders set the flanges round the bottom and then started to build up the outside. In this case the runners were brought out on the outside of the job. They had to use what was called a triangle to set up the spindle parallel, but from subsequent experience it was found that the best method was to use a 4-in. spindle. Whereas a 2-in. spindle moves, there is no movement in a 4-in. one.

The top of the job was a flat plate turned over on its back. A bed of grass was spread all over the plate and a number of small prongs were provided to hold the loam. This was swept up with loam and dried and was then ready to go on before the job was closed. The job was poured on the one side down the bottom using a 3-ton ladle and on the other side with a 2-ton ladle from the top. Two small ladles in the centre were used to warm the metal where it met.

DISCUSSION

MR. STONES thanked Mr. Watson for one of the most interesting Papers that had been delivered to the branch. Papers of this type were what members required and were of great practical value.

COL. GROSE mentioned a pipe which had an inside diameter of about 4 ft. 6 in., and was 7 ft. 6 in. long, and had about 1¼ in. metal. The thickness stick was put down when closing and showed that according to the thickness the mould was correct. He asked Mr. Watson to explain why, after the job was cast, the thickness of metal at the bottom was greater than at the top.

MR. WATSON could give no satisfactory explanation. In his experience he had not noticed a swelling on any jobs, but had found sometimes that the core got smaller at the bottom, giving more metal at the top. If swelling had occurred, they must have seen it. He had never used a thickness stick. In a plain job like the one mentioned by Col. Grose he would ignore all marks and depend on the joint. If the joint had been looked after, the marks could safely be ignored.

MR. HOLDSWORTH suggested that the variation in metal thickness might have been due to pressure, the downward strain being so great that the brickwork might tend to give.

Asked by Mr. Holdsworth how he mixed his loam, MR. WATSON said he used ordinary floor sand mixed with horse dung. If the sand was weak he would add a little red sand, but if too much was added the sand would crack. The loam was mixed by hand.

MR. STONES recalled that 20 years ago he had been told that when casting a pipe that size there would be a difference in the thickness of metal at the top and bottom, and that different contractions had to be allowed for.

MR. ALEXANDER asked whether there would not be solidification following the metal up, thus eliminating pressure.

The AUTHOR pointed out that the casting time was extremely short.

MR. WARD asked whether the base was parallel and whether the reduction of thickness appeared on the outside or inside.

MR. WATSON said that the stick would have to be less than 1 in. in order to work it down properly.

* A Paper delivered to the South African branch of the Institute of British Foundrymen.

Loam Work

Otherwise it could not be withdrawn. Unless the core and mould were calipered and they were sure that the mould was parallel from top to bottom, the thickness could not be accurately ascertained. He ran the metal from the bottom.

MR. STONES stated that the pressure from the top of the runner cope to the bottom would be about 30 lb. per sq. in., all of which was on the bottom.

MR. WATTS pointed out that in plastering it was necessary to work from the top down. In strickling, the sweep of the strickle was continually being made. Working upwards there would be a certain amount of droppings, causing roughage over the face that had been strickled. He asked whether Mr. Watson applied a finishing coat.

MR. WATSON said that he simply put his hand through to catch the spillage, and experienced no difficulty in finishing the job.

MR. WEST was inclined to make a joint in the middle and make the job in two parts.

The AUTHOR considered that if the stove was large enough this would not be necessary. Otherwise, the best plan would be to make a female joint, which was the main thing in loam work. In this way the mould could be lifted off and the core could be built in straight away. If the core was too large for the stove he would make a female joint in it and drop it down in the same way.

MR. HOLDSWORTH asked what method Mr. Watson adopted for flanges.

MR. WATSON said he had a dummy flange coming up. When he swept it up there was a loose piece in the board, which was taken away. On the particular job he had illustrated, only one off was required and this was therefore the cheapest method to adopt, since it saved time, strain, and unnecessary work.

Pipe Castings

COL. GROSE then sketched two pipes at an angle (Fig. 4), both pipes exactly the same dimensions otherwise. The problem was whether the pipes should be cast separately or whether the two should be cast in one mould. In the method adopted the two pipes were cast in one by separating with segmental cores perforated with runner holes. In this way two pipes were made in a little over the time which would have been taken to make one-half. The result was very satisfactory.

MR. WEST asked what would be the advantage of casting the two pipes in one. He considered that it would be preferable to make them separately.

COL. GROSE said that there had been very little room in the shop, as a large number of pipes were being made. Casting in one mould saved space. He also considered that it was just as difficult to make one half as two, and the two halves could be made in almost the same time as one.

MR. WEST said that the objection he saw to making

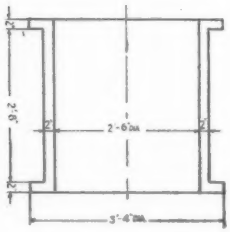


FIG. 1.

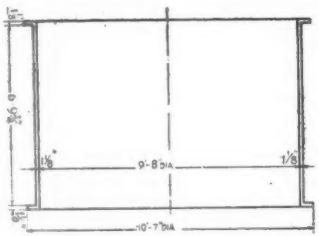
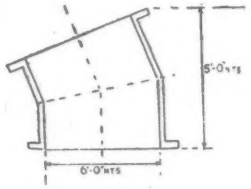


FIG. 3.



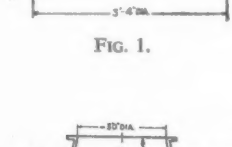


FIG. 2.

FIG. 4.

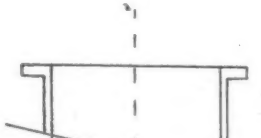


FIG. 5.

the two halves in one was the unnecessary amount of timber required in making the flange in the middle and also coreboxes.

COL. GROSE then described the pipe (as shown in Fig. 5) and how it was made by the loam method.

MR. STONES asked what method Mr. Watson adopted to ensure that the angle of the branches of a pipe were perfect. How was the pattern made and what steps were taken to ensure that the two branch pipes were at the right angle.

MR. WATSON said that in the first place the flange was struck up like a dummy flange. He started to build up from the bottom. A dummy pattern was built up in the sand. He put the thickness of metal on to the core in loam. After the inside was finished the spindle was in the centre and he could rest on the top to get the angles in position. He had a template on to the half of the joint. He got his prints on the strickle board as he went round. No trouble had been experienced with pressure on that job.

COL. GROSE said he made a similar pipe, which was only 6 in. at the top and about 5 ft. 6 in. deep (Fig. 6). On the first occasion he used ½-in. plate. He warned the moulder of the tremendous pressure, but the warning was disregarded and about a ton of metal came out at the side. Then 1¼-in. plate was used

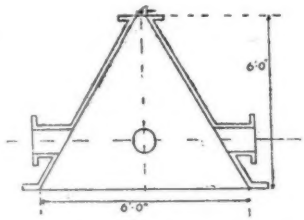


FIG. 6.

and bolts were put through to hold the plates together. This casting proved successful, but the third was also a failure because they reverted to the original plates.

MR. HOLDSWORTH stressed the importance of blackening and drying the core before applying the thickness of loam to form the pattern.

MR. WATSON said he preferred to strickle up his pattern first, then start building, after which he removed the thickness of metal. When he took the thickness of metal off there was still sufficient loam on the bricks. He did not put the mould in a stove before he built on it, but started straight away on the wet face.

MR. WEST favoured Mr. Holdsworth's method of making the core first, taking it away, and then putting wet blacking on.

MR. HOLDSWORTH said the method he adopted was to put the thickness of metal on the strickle, fastened on with two brackets.

The PRESIDENT said the discussion had shown how very rarely two foundrymen thought alike on the same job.

NEW PATENTS

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25 Southampton Buildings, London, W.C.2, price 1s. *each.*

573,310 AMERICAN CYANAMID COMPANY. Methods of concentrating ores.

573,381 FOUNDRY EQUIPMENT, LIMITED, and BEECH, A. S. Apparatus for filling containers, such as hoppers, with loose material.

573,389 WILKINS, R. A., and BUNN, E. S. Recovery of cuprous and ferrous materials from scrap.

573,595 CLARKE, E. J., and MUREX WELDING PROCESSES, LIMITED. Welding rods.

573,616 JOHNSON, MATTHEY, & COMPANY, LIMITED, CHASTON, J. C., and HEMMER, H. D. Silver solder alloys.

573,740 NEWTON, E. P. (Callite Tungsten Corporation). Method of making seamless tubes of refractory metals and the product thereof.

573,749 ENGLISH STEEL CORPORATION, LIMITED, SMITH, E. W., GRAY, B., and BURTON, H. H. Manufacture of metal ingots.

573,769 BUDD INDUCTION HEATING, INC. Loading and unloading apparatus, particularly for heat-treating apparatus.

573,783 SOC. RATEAU. Gas turbines.

573,813 UDY, M. J. Production of chromium compounds.

573,945 GLADWIN, F. L. Electric arc-welding and apparatus therefor.

573,983 BRITISH ALUMINIUM COMPANY, LIMITED, PULLEN, A. N. D., and RICHMOND, J. T. Treatment of aluminium and the like.

573,997 PNEULEC, LIMITED, and COWLAM, K. W. Means for controlling the flow of sand or other granular material from a hopper or like container.

574,002 AKT.-GES. BROWN, BOVERI & CIE. Firing arch for furnaces.

574,004 PRIESTMAN BROS., LIMITED, and PRIESTMAN, S. H. Grabs for lifting materials.

574,076 MALLORY METALLURGICAL PRODUCTS, LIMITED. Powder metal compositions.

574,088 MOND NICKEL COMPANY, LIMITED, and PFEIL, L. B. Heat-resisting alloys containing chromium.

574,163 MACRAE, J. C., and LEEDS FIRECLAY COMPANY, LIMITED. Domestic firegrates.

574,167 GRIFFIN, J. D. Electrically heated salt-bath furnaces.

574,174 WESTINGHOUSE BRAKE & SIGNAL COMPANY, LIMITED, KERSHAW, A. G., and KERSHAW, N. G. Axle counters for railway vehicles and the like.

574,213 ARON, E., POLLARD, E., and COOK, F. F. Injection moulding and die-casting apparatus.

574,243 BRAYSHAW FURNACES & TOOLS, LIMITED, BRAYSHAW, S. N., NEWMAN, F. C., and RUSHTON, F. Tool-supporting shelves or trays for furnaces.

574,258 BEARD, C. L. Punching and flanging sheet metal.

DEFECTIVE CASTINGS DUE TO FAULTY CORES IN A MALLEABLE FOUNDRY*

By S. LANE and G. W. FEARFIELD

It is generally recognised that all industries have their various problems to deal with, and each department in that industry has its own particular problems and difficulties. It is with this thought in mind that the Authors would consider core troubles and their immediate relation to defective castings, for, as may be appreciated, the loss of a casting due to faulty cores is an expensive item when the cost of raw materials is considered and the cost of labour in core production.

To discuss the various points which arise, it is proposed to group them as follows:—(1) Blown; (2) hot tears or pulls; (3) scabs; (4) distorted cores; (5) thin flanges; (6) badly shaped cores and inspection and conveyance, and (7) chills.

Blown Castings

Blown castings are attributed to many varying shortcomings in coremaking practice. The chief defects in this direction are due to hard cores and insufficient venting. (Hard cores arise through incorrect sand mixtures, this being in direct relation to bond.) Proper clean vents are most essential, but which of the following should be employed depends almost entirely on the size and shape of the core to be produced:—(*a*) The ordinary wire; (*b*) ashes which are used in various sizes according to the size of the core; (*c*) the open vent, which in general is composed of a vee-shaped channel cut on the joint of the core before being placed together, and (*d*) wax string used in the case of irregular shaped cores which would normally be difficult or even impossible to vent in the ordinary manner.

Hot Tears or Pulls

Hot tears or pulls are usually allied to hardness, heavy cores or undesirable sharp corners which have to be maintained. Methods designed to overcome the hard core problem have been indicated. If, however, a core is of standard manufacture and still proves to be too hard, the remedy is to produce a core which should only be a shell and collapse quickly and readily after casting. To obtain this shell the core should be hollowed out wherever possible to leave a minimum thickness of sand. Very often a plug may be employed to a useful purpose in that direction. Another method to counteract tears is the use of ties. These may be incorporated in the corebox wherever possible. If the tie cannot be incorporated in the box, the core may be sawn when dried. Fillets may be usefully employed to assist in avoiding pulls.

Scabbing

Scabbing may be caused by a weak sand or a core which is not properly baked, especially when the core lies in a sand drier, or in the case of a large core, in a metal drier, and again where a core is bedded in foundry black sand, which creates steam and destroys the face of the cores. To remedy these defects it is necessary to make sure all cores are completely dried. Where a runner is placed opposite the core, to obviate scabbing one should use a sand of increased strength immediately opposite the runner to resist the heat and the increased pressure of the metal. Blackleading is also a good remedy.

Distorted Cores

Distorted cores may be due to any of the following:—(1) Insufficient wiring; (2) poor equipment, which includes unevenly surfaced plates; (3) badly fitting driers and poorly clamped boxes, and (4) careless handling of green cores. The remedies are obvious—good level plates, accurately shaped driers, strong wires and irons. Core wires should be properly placed in the cores, whilst the even ramming of the core is also essential.

Thin flanges are often due to cores lifting in the mould through insufficient prints or damaged prints on the cores. The excessive rapping of coreboxes is also frequently a contributory cause to thin flanges. The obvious solutions are to make sure that sufficient prints are available on the cores and that the initial prints are secured to the main body of the core. To avoid excessive rapping of boxes a liberal amount of taper should be allowed wherever possible.

Badly Shaped Cores Through Jointing

Where half-cores are mass-produced, it becomes necessary to provide simple means of jointing them. Often through badly jointed cores, circular holes are apt to become elliptical. This can easily be overcome by the following means. To allow for depreciation in the depth of the core, the half box may be built up $\frac{1}{16}$ in. above the required finished size. The jig should be employed to remove this excess on the joint, but the jig itself should be $\frac{1}{32}$ in. greater than the required finished size to allow for the loss on the joint due to the varying grain size of the sand. A metal strickle may be used to remove the initial excess on the joint of core after placing in the jig.

Use of Chills

Scrap castings may be caused by ill-fitting, distorted or misplaced chills. Therefore all chills used in cores should be of good shape, and have a good bearing to secure them into the core and so prevent them being easily rammed out of place. The coating of the chills is very important, and one in general use is that of oil and blacklead. It should be emphasised, however, that a *clean* chill is essential.

In conclusion, to avoid a high percentage of scrap castings it cannot be over-emphasised that inspection is an all-important factor. Employing core inspectors easily repays the cost in a short time. All cores entering the foundry should be carefully inspected for the following details:—(1) Good clear vents; (2) cleaning, involving the removal of all fins; and (3) core gauging and packing ready for conveying to the foundry—this last being a very important factor. The conveyance of cores to the foundry is apt to be overlooked, but, however, on analysis a fair percentage of castings is scrapped through cores being rubbed and damaged during this transit, and it is felt this problem should be given more consideration.

*An entry for a short Paper competition organised by the East Midlands branch of the Institute of British Foundrymen.

THE GASSING OF BRONZES BY REACTION WITH MOULDING AND CORE SANDS

By W. T. PELL-WALPOLE, B.Sc., Ph.D.

(*Continued from page* 167.)

Effect of Pouring Conditions

(*a*) *Pouring Temperature.*—The effect of temperature on the reaction between bronze and the moisture in the bonded sands was studied by variation of the pouring temperature from 1,150 to 1,300 deg. C. for a number of differently bonded sand mixtures (Table XIV). In all cases the extent of gassing increases very markedly with pouring temperature, implying that in order to minimise gassing in practice, it is essential that the lowest pouring temperature consistent with efficient feeding should be used in all processes in which the molten bronze comes into contact with bonded sand, *e.g.*, in casting billets in sand, cored sticks, or chill castings poured through moulded sand bowls.

(*b*) *Pouring Rate.*—The standard pouring rate used in these investigations (8 lbs. per min.) was that determined previously to give a minimum shrinkage porosity (> 1 per cent.) in degassed chill ingots of the size used and cast as described previously. To determine the effects of reaction gas in the presence of shrinkage, a number of tests were made with a higher pouring rate (16 lbs. per min.), which normally gives about 2.5 per cent. shrinkage porosity in gas-free ingots. The results (Table XIV) show that the effects of gas and shrinkage are not additive, the porosity values of gassed melts being independent of pouring rate. This indicates that melts which pick up gas during pouring may with advantage be poured sufficiently rapidly to allow the lowest possible to be used. This procedure minimises gas absorption and does not introduce additional shrinkage porosity, such as would occur if a *gas-free* melt were poured rapidly.

On the contrary, when shrinkage effects cannot be entirely avoided in a casting, the presence of a small amount of gas, such as that introduced by sea sand bonded with a commercial starch bond, actually improves the mechanical properties at the centre of the casting (cf. Nos. 210, 211, Table XIV). This is probably due to a partial elimination of the central shrinkage cavities, *i.e.*, gas evolved in the outer layers of the ingot during solidification exerts sufficient pressure to prevent the feeding of liquid metal away

TABLE XIV.—*Effect of Melting and Pouring Conditions on the Gassing Action of Sands and Bonding Agents (all Baked ¼ hr. at 150 deg. C.) on 2B8 Bronze.*

Ingot No.	Sand Mixture.	Wet Wt. Grm.	Dry Wt. Grm.	Pouring Rate Lb./min.	Pouring Temp. Deg.C.	Observed Densities.				Tensile Properties.				Gassing Index.		Analysis.	
										Upper T.P.		Lower T.P.					
						Head.	1½ in. Bar.	Upper T.P.	Lower T.P.	U.T.S.	El. Per Cent.	U.T.S.	El. Per Cent.	P_W.	P_D.	Sn Per Cent.	P Per Cent.
183	Red sand plus 50 per cent. pure colloidal clay ..	108	54	8	1,150	8.61	8.66	8.67	—	23.7	15	—	—	1.8	3.6	9.7	0.71
185	Ditto	82	41	8	1,250	8.42	8.62	8.59	8.65	25.4	22	23.8	17	3.5	7.0	—	—
*184	Ditto	64	32	8	1,250*	8.44	8.47	8.43	8.51	17.5	3	21.0	7	6.3	12.6	—	—
161	Red sand plus 5 per cent. flour ..	85	58	8	1,150	8.65	8.65	8.62	8.61	22.1	8	22.6	7	2.3	3.4	10.4	0.68
163	Ditto	91	60	8	1,200	8.54	8.63	8.64	8.61	23.1	13	22.4	12	2.6	3.9	9.8	0.71
166	Ditto	90	60	8	1,250	8.49	8.62	8.54	8.61	24.1	17	22.6	12	2.8	4.2	9.7	0.69
220	Flour alone ..	53	21	8	1,250	8.56	8.57	8.57	8.56	24.2	12	23.6	12	5.3	13.6	9.9	0.78
221	Ditto	50	21	8	1,300	8.59	8.48	8.47	8.49	22.2	10	22.7	13	7.0	17.5	10.0	0.76
228	Oil/starch alone	53	12	8	1,200	8.69	8.71	—	8.72	—	—	27.8	27	2.4	10.8	10.0	0.74
232	Ditto	47	10	8	1,300	8.70	8.71	8.70	8.67	28.5	33	25.6	17	2.6	12.5	10.1	0.76
208	Sea sand plus 10 per cent. aluminous cement	85	63	16	1,250	8.52	8.62	8.61	8.67	20.6	6	19.6	5	3.0	4.1	9.8	0.80
239	Ditto	80	59	8	1,230	8.57	8.58	8.57	8.58	24.9	10	22.4	9	3.4	4.6	10.0	0.77
199	Sea sand plus 10 per cent. pure colloidal clay ..	87	64	16	1,200	8.43	8.56	8.53	8.56	19.6	5	19.6	6	3.8	5.1	10.1	0.80
245	Ditto	90	67	8	1,250	8.49	8.55	8.55	8.61	25.1	20	23.2	15	3.5	4.7	9.9	0.71
204	Sea sand plus 10 per cent. commercial starch	81	60	16	1,250	8.47	8.52	8.52	8.52	19.6	4	18.8	5	4.3	6.4	10.1	0.81
205	Sea sand plus 10 per cent. flour	84	56	16	1,225	8.43	8.48	8.49	8.42	21.6	8	18.8	5	4.8	7.2	10.1	0.80
206	Sea sand plus 10 per cent. dextrin	87	65	16	1,250	8.25	8.43	8.29	8.43	18.8	5	17.1	4	5.6	7.5	10.3	0.79
210	Sea sand plus 10 per cent. commercial starch	82	41	16	1,250	8.45	8.62	8.59	8.62	22.5	8	20.4	7	3.3	6.6	10.3	0.80
211	None	—	—	16	1,250	8.63	8.65	8.68	8.63	19.2	5	18.9	4	—	—	10.0	0.79

* Not degassed. Cf. No. 185. All other melts degassed with oxidising flux.

The Gassing of Bronzes

from the hotter central parts of the ingot, and thus decreases the extent of shrinkage porosity in the latter. This effect is well known in die-casting practice, in which the metal is often intentionally gassed to give a better distribution of porosity, since shrinkage effects cannot be eliminated by control of casting conditions, due to the complex form and variations in section of the shaped castings.

Recent work by Baker and Glaisher,[1] referred to previously, has shown similarly that a controlled quantity of gas in incompletely fed sand castings in phosphor bronze may greatly improve pressure tightness by ensuring a more uniform distribution of porosity. The procedure used in the present tests, *i.e.*, lining the pouring funnel or runner bush with a gassing mixture of known characteristics, offers a simple method of controlled regassing which might easily be employed in the foundry for this purpose.

Effect of Original Gas Content of the Bronze

In processes in which some gassing is bound to occur during casting, by reaction with sand, it seemed questionable whether preliminary degassing of the bronze was worth while. An experiment was carried out with a degassed and an untreated melt, both poured through a funnel lined with a sand bonded with pure colloidal clay. The untreated melt was much more severely gassed than the flux-treated melt (cf. Nos. 184, 185, Table XIV), hence the preliminary degassing was still beneficial. Moreover, the extent of gas pick-up during melting varies with the materials in the charge, furnace atmosphere, gases in refractories, etc., so that standardisation of product would be impossible without preliminary degassing, even if the extent of gassing during casting were controlled. In cases where regassing during casting is intentional (for better distribution of shrinkage), preliminary degassing of the melt is clearly an essential to control of the process.

REFERENCE

[1] W. A. Baker, F. C. Child, and W. H. Glaisher, J. Inst. Metals, 1944, **70**, 373.

(To be continued.)

SUMMER SCHOOL ON THEORETICAL PHYSICS IN INDUSTRY

A Summer School will be held in the H. H. Wills Physical Laboratory in co-operation with the Institute of Physics, from May 30 to June 6. The subjects to be studied will cover the general field of conduction of electricity in non-metals and will include luminescence, dielectric phenomena and reactions in solids. The course is intended mainly for members of the research staffs of Government and industrial laboratories who are engaged on experimental research in these subjects. Further particulars may be obtained from the Secretary of the Institute of Physics, 19, Albemarle Street, London, W.1.

SEALING BRONZE PRESSURE CASTINGS THROUGH HEAT-TREATMENT

Lt. Fred L. Riddell, of the American Naval Research Laboratory, has detailed in the American "Foundryman" the results of a series of tests carried out with the object of ascertaining the real worth of the well-known trick of heat-treating pressure-resisting bronze castings with the object of sealing microporosity. The Author has drawn the following conclusions:—The pressure tightness of leaky bushings of gunmetal, valve bronze and hydraulic bronze was improved when they were annealed for 3 hr. at 650 to 700 deg. C. in an air or oxygen-rich air atmosphere. No sealing whatever took place in a hydrogen atmosphere. When bushings previously improved in pressure tightness by annealing in the oxygen-rich air were re-annealed in hydrogen, the pressure tightness decreased by 25 to 50 per cent. Removing the outer layer of oxide scale after sealing in air did not cause appreciable loss in pressure tightness provided that the bushings were annealed for 3 hr. at the necessary temperature.

The bronze specimens used in this investigation were sealed by the formation of oxides of larger specific volume than the base metal. The oxide layer on the inside of fine shrinkage cracks tended to close the openings provided that the cracks were of sufficient fineness. The tendency for leakage of unsound bronze may become serious after several years of service, and the wear resistance of moving parts is certainly lower with unsound metal.

The short-time pressure test at room temperature is not equivalent to conditions of service, which include the factors of corrosion, abrasion, application of stress, wear and changes of temperature. It is believed that the annealing of leaky bronze castings to improve pressure tightness should be exercised with care until such time as information may be obtained over a period of years on the performance of sealed castings in various services.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION announce that Mr. Frank E. Wartgow, formerly connected with Hasbrouck Haynes Engineers, Chicago, and American Steel Foundries, has joined their headquarters staff in Chicago to assist with certain phases of the Association's plan for their 50th anniversary year, 1946. He becomes the second member of the staff acquired recently to carry out an increased programme of activities; Mr. Herbert F. Scobie, formerly instructor in foundry practice at the University of Minnesota, Minneapolis, joined the staff in October. Mr. Wartgow will be occupied at the outset with arranging and staging the anniversary foundry congress and foundry exhibition in Cleveland next May 6 to 10, and thereafter will turn his activities to the co-ordination of A.F.A. chapter work and programmes. Mr. Scobie, whose duties will be directly connected with the Association's increased activities along educational lines, will be working closely with the Committee on Co-operation with Engineering Schools and Colleges and other committees of the A.F.A. concerned with training and educational problems.

PRODUCTION CONTROL

DISCUSSION ON MR. A. B. LLOYD'S PAPER

Mr. A. B. Lloyd, M.A., repeated his lecture on "Some Principles of Production Control and Their Application to the Manufacture of Steel" before the East Midlands branch of the Institute of British Foundrymen at the December meeting held at Loughborough. It was printed in our issue of August 31, 1945, *page* 359 et seq.

The discussion was opened by MR. GOODWIN, who commented that to members of the "old school" the system seemed complicated and asked for details of the personnel of the methods department.

MR. LLOYD, in reply, said the man in charge of the methods department must be a practical foundryman, with detailed knowledge of patternmaking, moulding, feeding and fettling problems. A draughtsman, with a bent towards foundry problems, was also an asset. If there was a highly repetitive job, where the production of thousands of castings per week was required, he thought it was true to say that it was best to make a full-scale drawing of the feeding, gating, etc., if good results were to be obtained. In the case of motor-car cylinders, he did not think just a drawing of the block was adequate to give the patternmaker proper guidance. The whole of the moulding tackle and coreboxes should be drawn out in detail.

On the other hand, when dealing with jobbing work, the head of the methods department would then be sent to the foundry. That was not taking anything from the foundry foremen. It was found that, when the cost of different methods of moulding, etc., was ascertained, it was quite possible by doing a job scientifically, at least to halve production costs. If the job just went into the shop without any indication of how it was to be made, the foreman was called upon to make a snap decision as to the method, and had not the time or the facilities to give the job the detailed consideration it needed. Inevitably, uneconomical production would result.

Absenteeism and Planning

In reply to a question by Mr. Measures as to provision for absenteeism, MR. LLOYD said that, curiously enough, he had always found it to be reasonably predictable, although it could get out of hand during the winter months. Some margin should be allowed for it in determining capacity. How to prevent absenteeism was a question for the personnel manager.

System and Time Element

MR. HALLAMORE asked how the rate was actually fixed before the job went to the moulder, and did Mr. Lloyd have an idea as to how long it would take to make the castings? As to the receipt of an order in the works, it appeared that it had to go through various departments and various files, etc. It would be interesting to learn of the time taken for an order to reach the foundry. Referring to "loading," was it noticed that one was more inclined to impose loading on the coreshop rather than the foundry, because that appeared to be necessary in many foundries, where the production in the foundry was quicker than the coreshop? Referring to the chart where a moulder had 10 different items to make in one day and finished work at 3.30 p.m., what did he do for the rest of the day? It seemed rather unnecessary there should be so many changes on one machine. During the war there were orders in hand 12 weeks ahead, but now it was a case of working hand-to-mouth. Did these changes affect the planning system?

MR. LLOYD said, in reference to rate fixing and the time determined, that in 95 per cent. of the cases this was fixed before the job was done. Circumstances were exceptional when there was an extremely long run on an entirely new job, and in such cases he did not fix the time initially, for the simple reason that, when a man started on a job of fresh design, his bonus at the beginning was not very good. Thus it was usual to say: "Here is so much bonus; we will see how you get on." The firm generally paid something less than average bonus, and then, when the job had settled down, the time was fixed. The average time to get a job into the foundry, taking into account patternmaking and the passing of papers from one department to another, was from four to seven days, that was assuming there was no more than an average amount of patternwork involved. He agreed that the loading of the coreshop was a major problem. He believed he showed on one of the planning charts the number of coremaking hours against the foundry hours. It was obviously useless putting jobs in the foundry involving a lot of cores, when the moulds were laid out and had no cores.

As to the moulder who had 10 different items in one day and finished work at 3.30 p.m., it should be pointed out that that slide was copied from an actual programme made about three years ago, with the items disguised so as to be unrecognisable. The real trouble in this case was the shortage of moulding boxes. If there was a full day's run on one item, it would be found that by 12 o'clock all the boxes of a particular size were full of sand. The management would have made the runs longer had they been able to do so. As regards finishing work at 3.30 p.m., it was another case of suffering from an overfull order-book at that time, and it was difficult to keep all customers quiet. It was decided, therefore, to keep the jobs which had to be brought forward at the last minute until then. As far as living from hand-to-mouth was concerned, the procedure did not need to be quite so elaborate as was outlined, and since the end of the war the production control staff had been considerably reduced, but very little had, however, been altered in principle.

Regulated Hours

MR. HALLAMORE said he understood that regulated hours were posted up each week. Did that mean those men were scheduled to work so many hours? It was also mentioned that it was desired that the men should make what the management wanted. It appeared from the working of the system that when a man finished a job at a given time, he had nothing more to do.

MR. LLOYD, in reply, said the regulated hours were the normal working hours. If there was the possibility of congestion in the shop, then it might be insisted that

Production Control

the staff would work 55 hours. The idea of the regulated hours was to enable the production control department to know where it stood. If there was a heavy load in a particular shop, the manager would plan his programme accordingly, and the increased time, including overtime, would be posted in the shop. It was possible that Mr. Hallamore had slightly misunderstood one particular remark. What was implied was that when a man was working with loose patterns, it was often found that the castings were despatched before the moulder had booked them. The moulder was tempted to use the method of recording his production as a kind of bank, turning in jobs in accordance with his requirements for ready cash. To safeguard against this, it was important that production was booked by an independent observer.

Applicability of the System

MR. P. A. RUSSELL, B.Sc., said he appreciated the necessity for an elaborate production control in a large foundry for this class of work, but he could not see that it was so necessary and applicable for jobbing work. Mr. Measures had raised the question of absenteeism, and whilst he agreed that this averaged out over the whole works, violent fluctuations occurred in certain shops which threw production plans out of gear. He thought that a possible weakness of the system was the risk of inadequate liaison, particularly from the point of view of improvements in foundry methods not being handed on to the methods control department. Also, the production control department must be kept in very close touch with fluctuations in the capacity of the moulding and coremaking departments. He asked for further information as to how the interchange of information was effected.

MR. LLOYD said the question arose as to whether Mr. Russell had missed one of the main points of the Paper. One of the things that he intended to make clear was that no system would of itself operate a factory. There was only one person who could do that, and that was the managing director. Co-ordination from the top was essential in any business. For instance, if in the methods department there were people applying their own ideas as to methods on their respective jobs, the works did not get the benefits that accrued through all the ideas being properly co-ordinated. The object of the methods department was to achieve that in a practical way.

The answer to the last query was that interchange of information from one department to another was effected by mutual consultation. Even so, it was often found that one manager did not get much "change" from another. That was then a job for the director concerned, who must get the two men together, and reconcile conflicting viewpoints. In the small concern, of course, there was no need to have all this consultation, but in the larger firm it was really necessary. As far as absentees were concerned, absenteeism, of course, could be controlled from the personnel side. It was surprising what a well-intentioned lady visitor could do in bringing absentees back to work.

Incidence of Scrap on Planning

MR. HORNBY said that, if it were assumed that a customer placed an order for 1,000 castings, and it was decided that this order would spread over a period of 20 weeks, he may be told that he could receive 100 castings each two weeks. As this job progressed through the cycle, it would be found that at three stages scrap was apparent: (1) at the mould knockout station; (2) after sand blast; and (3) at the final inspection. Would Mr. Lloyd please indicate what system he used to complete the original order?

MR. LLOYD said scrap was one of the things one could deal with between 3.30 p.m. and 5.30 p.m. With a long recurring job, however, scrap castings could be accumulated, as they were recorded day by day and replaced in a single batch at the end of the order.

MR. DUNLEAVY said he could neither agree nor support Mr. Lloyd when he said that the personnel manager should visit the workers, asking them to return to work. He believed that it was his duty to be in the works. It was a retrograde step to send a lady visitor to see absentees. The next point was that, if the cores were planned and made, and then it was found that through absenteeism or other causes the moulds were not made, replanning was difficult. He felt that the welfare of the foundry industry would be materially advanced by the methods department, as suggested by the lecturer.

MR. LLOYD said it was hard to see why the coreshop should go so far ahead, and if things became so bad, he would close the shop. Quite seriously, though, one could get moulders making cores, and he had done this quite recently. As for who was responsible for the scrap, he would say the foreman was responsible for all scrap, because if he thought a certain method was wrong, he should have said so. He had no sympathy with the foreman who made a quantity of scrap and then said, "I knew we were courting trouble." He also thought it was a good thing to have a meeting each week at which the foreman was present to review the scrap situation.

After Mr. P. A. Russell had proposed and Mr. Measures seconded a vote of thanks to the lecturer, the meeting closed.

U.S. PLANS FOR IMPORTING COPPER IN 1946

The copper purchase programme conducted by the U.S. Office of Metals Reserve until its discontinuance in October, 1945, is being re-established, the Reconstruction Finance Corporation has announced. Action is being taken at the request of the Office of War Mobilisation and Reconversion, upon the recommendation of the Civilian Production Administration. The Office of Metals Reserve plans to purchase copper of foreign origin during the first six months of 1946 at the rate of 20,000 tons per month. The total quantity will be in addition to any commitments at present outstanding for the purchase of foreign copper.

MR. ARTHUR EDGAR WILKES, who has died at Pelsall, was a well-known ironfounder and engineer.

INSTITUTE ELECTS NEW MEMBERS

At a meeting of the Council of the Institute of British Foundrymen, held at the Midland Hotel, Manchester, on February 1, the following were elected to the various grades of membership.

FIRST LIST

As Subscribing Firm Members

Alloy Diecast (Pty.), Limited, 76, Bunsen Street, Industria, Johannesburg (representative, C. W. Tocknell); Clayville Foundry (Pty.), Limited, Olifantsfontein, Transvaal, South Africa (representative, J. J. Van Ryneveld).

As Members

J. R. Binley, metallurgist, Wycliffe Foundry Company, Limited, Lutterworth; J. B. Binnie, manager, iron and steel department, Sheepbridge Coal & Iron Company, Limited, Chesterfield; R. Blaik, assistant foundry manager, United Engineers & Founders, Limited, Swansea; P. M. R. Bower, assistant foundry manager, Barnards, Limited, Norwich; E. Clipson, foundry manager, William Foster & Company, Limited, Lincoln; W. Hayward, representative, I. & I. Walker, Rotherham; W. J. Hobbs, foundry manager, J. Hampton, Limited, Lincoln; J. G. Hodgson, technical inspecting officer, Admiralty Offices; J. W. C. Johnson, works manager, Borough Engineering Works, Limited, Luton; R. P. Jones, director, John Jones & Sons, Limited, Loughborough; W. B. Kemmish, metallurgist, Jarrow Metal Industries, Limited; L. A. Knight, general manager, D.H. Diecasting Company, Limited, Slough; A. L. Ladeueze, works manager, H. J. Maybrey & Company, Limited, London; H. M. Laplanche, metallurgical engineer, Laboratoire des Fonderies, Paris; P. D. Liddiard, metallurgist, Glacier Metal Company, Limited, Alperton; J. J. Marais, chemist and metallurgist, G. & W. Base, Pretoria; F. A. Martin, managing director, Clyde Steelworks, Limited, Sheffield; T. Shaw, foundry manager, Chamberlin & Hill, Limited, Walsall; E. G. Smith, manager, Wm. Jacks & Company, Limited, London; G. A. Tomkinson, foundry manager, D. Napier & Son, Limited, London.

As Associate Members

W. Ackroyd, foundry manager, J. Stirk & Sons, Limited, Halifax; R. M. Ainsley, head, heat-treatment department, Noble & Lund, Limited, Gateshead-upon-Tyne; A. Allen, foundry foreman, Coneygre Foundry, Limited, Tipton; F. R. H. Allon, analytical chemist, Jarrow Metal Industries, Limited; R. S. Barrie, M.I.Mech.E., managing director, E. A. & H. Sandford, Limited, Gravesend; B. W. Bloodworth, coremaker, Messenger & Company, Limited, Loughborough; W. Brown, foundry foreman, Hadfields, Limited, Sheffield; F. J. Charlton, foundry foreman, Pease & Partners, Limited, Darlington; S. G. Clough, designer and engineer, Crofts (Engineers), Limited, Bradford; F. M. Davis, assistant chemist, Jarrow Metal Industries, Limited; R. E. Dawkins, foreman patternmaker, Aveling-Barford, Limited, Grantham; J. T. Edgington, foreman moulder, English Electric Company, Limited, Rugby; J. P. Fairclough, moulder, J. Dale, Limited, Enfield; W. Fraser, assistant foundry metallurgist, Armstrong, Whitworth, Limited, Newcastle-upon-Tyne; W. Garforth, draughtsman, Dowson & Dobson, Limited, Johannesburg; G. H. Garside, moulder, H.M. Dockyard, Plymouth; A. Gill, moulder, Roberts Castings, Limited, Huddersfield; J. E. Gillett, moulder, Mallory Metallurgical Products, Limited, Wembley; R. L. Green, process metallurgist, Langley Alloys, Limited; J. F. Grimshaw, iron moulder, Smith & Fawcett, Limited, Bradford; W. Hartley, foreman patternmaker, J. Stirk & Sons, Limited, Halifax; S. N. Iyengar, foundry engineer, Massey's Engineers, Madras; C. E. E. Jones, foundry estimator, English Steel Corporation, Limited, Sheffield; C. W. Jones, foreman coremaker, Coneygre Foundry, Limited, Tipton; D. S. Keenlyside, metallurgical analyst, Jarrow Metal Industries, Limited; J. Kerfoot, foreman moulder, Messenger & Company, Limited, Loughborough; A. J. Lawson, patternmaker foreman, English Electric Company, Limited, Rugby; D. W. Morris, assistant foundry foreman, Vickers-Armstrongs, Limited, Dartford; A. H. J. Morrish, metallurgist, Midland Electrical Manufacturing Company, Limited, Birmingham; G. J. Muirhead, development engineer, D.H. Diecasting Company, Limited, Slough; W. H. Mundy, foundry foreman, Hadfields, Limited, Sheffield; A. Mutter, assistant sample passer, G. Blair & Company, Limited, Gateshead-upon-Tyne; S. J. McClelland, journeyman, Phœnix Foundry, Hudson & Hopkins, South Africa; R. D. Paterson, metallurgical chemist, Manganese Bronze & Brass Company, Limited, Ipswich; J. W. Percy, steel foundry foreman, Hopkinson, Limited, Huddersfield; J. C. Robinson, melting shop foreman, G. Blair & Company, Limited, Gateshead-upon-Tyne; C. Rope, foreman moulder, A. E. Rofe & Son, Dartford; R. W. Suckling, foundry foreman, Sturla's Bronze Foundry, Waltham Cross; *R. Finlay, senior metallurgical chemist, Jarrok Metal Industries, Limited; *A. P. Scattergood, assistant foundry manager, Qualcast, Limited, Derby.

* Transferred from Associate.

As Associates (over 21)

J. G. Gilbert, chargehand, C. A. Parsons & Company, Limited, Newcastle-upon-Tyne; C. R. Lees, chargehand, C. A. Parsons & Company, Limited; A. Lumsden, floor moulder, Noble & Lund, Limited, Gateshead-upon-Tyne; M. Pattinson, floor moulder, Crookhall Foundry, Newcastle-upon-Tyne; G. S. R. Taylor, radio mechanic, Army.

As Associates (under 21)

J. A. Baker, assistant metallurgist, Crane, Limited, Ipswich; H. Greenwood, moulders' apprentice, Hepworth & Grandage, Limited, Bradford; J. R. Hawley, foundry control student, S. Russell & Sons, Limited, Leicester; C. McCombe, apprentice metallurgical chemist, C. A. Parsons & Company, Limited, Newcastle-upon-Tyne; N. P. Partlow, apprentice, Higgs Motors, Limited, Birmingham; R. C. F. Pinkney, apprentice foundry metallurgist, Reavell & Company, Limited, Ipswich; A. J. Reed, laboratory assistant, Jarrow Metal Industries, Limited; J. Richman, engineering apprentice, Cocksedge & Company, Limited, Ipswich; S. A. Toach, foundry student, S. Russell & Sons, Limited, Leicester.

Institute Elects New Members

SECOND LIST

As Members

R. Hunter, director, Clyde Alloy Steel Company, Limited, Motherwell; I. K. MacGregor, metallurgical engineer, Campbell, Wyant & Cannon Foundry Company, Muskegon, U.S.A.; †J. Cameron, ironfounder, Cameron & Roberton, Limited, Kirkintilloch; †R. S. M. Jeffrey, metallurgist, Cameron & Roberton, Limited.

† Transferred from Associate Member.

As Associate Members

A. J. Bern, temperature recorder, Rolls-Royce, Limited, Renfrewshire; H. Campbell, steel salesman, Clyde Alloy Steel Company, Limited, Motherwell; W. Gray, foreman ironmoulder, Cameron & Roberton, Limited, Kirkintilloch; R. M. Hamil, foreman ironmoulder, Cameron & Roberton, Limited; H. H. Hamilton, patternmaker, Rolls-Royce, Limited, Renfrewshire; R. M. Hunter, engineering patternmaker, Tecalemit, Limited, Brentford; J. Meek, assistant works manager, Cameron & Roberton, Limited, Kirkintilloch; W. D. Mitchell, patternmaker, Rolls-Royce, Limited, Renfrewshire; W. Pollock, foreman moulder, Cameron & Roberton, Limited; H. A. Smith, assistant foundry superintendent, Commonwealth Aircraft Corporation, Melbourne; J. Turpie, assistant metallurgist, Renton & Fisher, Limited, Bathgate; J. P. Wilson, foreman moulder, John Lang & Sons, Limited, Johnstone; †J. D. Dawson, engineering draughtsman, Ashmore, Benson, Pease & Company, Limited, Stockton-on-Tees.

† Transferred from Associate Member.

As Associate (over 21)

L. Gateman, castings inspector, Ashmore, Benson, Pease & Company, Limited, Stockton-on-Tees.

THIRD LIST

As Members

P. B. Higgins, director, Yorkshire Engineering Supplies, Limited, Leeds; J. Allison, patternmaker, Hargreaves & Gott, Limited, Rochdale; J. Machin, foundry manager, Ministry of Supply; J. R. Marsh, assistant foundry manager, Vickers-Armstrongs, Limited, Ulverston; T. A. Maxwell, foundry manager, Broadheath Aluminium Bronze Company, Limited, Altrincham; F. Spicer, foundry manager, Glyco Metal Company, Limited, Manchester.

As Associate Members

E. Challinor, foreman, Metropolitan-Vickers Electrical Company, Limited, Manchester; F. Chiles, technical sales manager, Sternol, Limited, London; R. G. Greening, senior draughtsman, Brown, Lenox & Company, Limited, Pontypridd; J. Johnson, ironmoulder, Bolton; A. H. Pople, metallurgist, Whitehead Iron & Steel Company, Limited, Newport, Mon.; G. A. Southern, sand moulder, Metropolitan-Vickers Electrical Company, Limited, Manchester; H. Tattersall, designs superintendent, Thomas Ashworth & Company, Limited, Burnley; W. L. Tomkins, works engineer, Brown Lenox & Company, Limited, Pontypridd; A. Tweedale, works manager, E. S. Lord, Limited, Rochdale.

As Associates (over 21)

W. H. Poynton, foreman patternmaker, Whitehead Iron & Steel Company, Limited, Newport, Mon.; G. Seneviratne, D.I.T., foundry apprentice, Jinasena & Company, Colombo, Ceylon; F. C. Wilkins, steel foundry foreman, Westgate Works, Newport, Mon.

As Associates (under 21)

F. Clements, apprentice, Williams Alexandra Foundry, Limited, Cardiff; L. G. Maidment, apprentice, Williams Alexandra Foundry, Limited; S. F. Maidment, apprentice, Williams Alexandra Foundry, Limited; K. W. A. Wilkins, apprentice, Williams Alexandra Foundry, Limited.

As Subscribing Firm Members

Prince-Smith & Stells, Limited, Burlington Shed, Keighley, Yorks, worsted machinery makers, ironfounders, etc.; Renfrew Foundries, Limited (representative, J. Vickers, Hillington, Glasgow, S.W.2), light alloy founders.

As Members

J. Nicholl, director, Nicholl & Wood, Halifax.

As Associate Members

H. Haigh, foundry foreman, Sagar-Richards, Limited, Luddendenfoot, Yorks; N. Pattinson, foreman smelter, Vickers-Armstrongs, Limited, Newcastle-upon-Tyne.

As Associate (over 21)

R. S. Smith, journeyman moulder, C. A. Parsons & Company, Limited, Newcastle-upon-Tyne.

DETERMINATION OF NICKEL

A rapid, accurate method for determining nickel in steel and nickel ore has been developed and described in an article entitled "Polarographic Determination of Nickel in Steel and Nickel Ore," by Philip W. West and James F. Dean, published in "Industrial and Engineering Chemistry," Vol. 17, No. 11. The method is based on the use of the polarograph with sodium fluoride serving as the supporting electrolyte. When nickel is present in quantities ranging between 1 and 5 per cent., accuracies of approximately 1 per cent. can be expected. The method is said to compare favourably with spectrographic techniques.

STEEL PRICES IN EIRE

The Eireann Minister for Industry and Commerce has made an Order, with effect as from February 6, revoking the Emergency Powers (Imported Mild Steel) (Maximum Prices Order), 1945, and fixing maximum prices as follows for both home-produced and imported mild steel:—When sold by wholesale, £33 10s. per ton, f.o.r.; when sold retail, £38 10s. These are basic prices, and the Order provides for additional charges for "extras" in accordance with the custom of the trade.

DALE
DALE
The High-Quality Iron for High-Duty Castings.
Made in seven standard grades or to individual requirements, this iron has a close grain structure and fine graphitic carbon content. It replaces Hematite, and tones up high phosphorus irons.
We also make Dale Refined Malleable Iron to any required specification.
STANTON
DALE Refined PIG IRON
THE STANTON IRONWORKS COMPANY LIMITED
NEAR NOTTINGHAM

PERSONAL

MR. WILLIAM WILSON HALLIDAY has been elected a director of Engineering Components, Limited.

MR. J. F. STANIER, managing director of the Renishaw Iron Company, Limited, left recently on a visit to Germany on behalf of the Government.

MR. PAUL W. BAKER, assistant works manager of Baker, Perkins, Limited, engineers, Westwood Works, Peterborough, has been appointed a director of the concern. He joined the business in September, 1914, and later spent about two years with Baker, Perkins, Inc., in the United States.

MR. J. W. MURRAY, who has been chairman of Harrison (Birmingham), Limited, brassfounders, since 1928, has retired from the board. MR. E. C. B. ROWLEY, who has been the director responsible for the sales organisation of the company since 1929, has been appointed chairman. MR. J. H. GRIFFITHS has been elected to the board.

MAJOR HUGH NETTLEFOLD, of Nettlefold & Sons, Limited, London, has been appointed chairman of the board of management of the Royal Metal Trades Pension and Benevolent Society. He succeeds Capt. Norman A. Dore, former general manager of the London branch of Baldwins, Limited, who has resigned the office after having held the chairmanship since 1935.

MR. A. E. MELLERUP, a director of R. A. Lister & Company, Limited, agricultural and general engineers, Dursley, Glos., is retiring from the board of directors. Mr. Mellerup carried out considerable work in connection with the reorganisation of Blackstone & Company, Limited, engineers, Stamford, Lincs., which was amalgamated with Lister & Company, Limited, in 1936.

MR. R. SLATER has been appointed works manager of Whessoe, Limited, in succession to MR. W. J. HARRISON, who has retired. He was formerly production engineer. MR. A. PUTTICK, formerly of the company's technical department at Darlington, has been appointed research engineer, and MR. J. V. WOODMAN has been appointed technical sales engineer at the London office.

MR. E. B. GRAHAM, technical director of Specialloid, Limited, is at present in Canada negotiating regarding the formation of Specialloid (Canada), Limited. During his tour Mr. Graham will be flying to the U.S.A. with the object of inspecting piston plants and ascertaining the latest developments which have taken place there in connection with pressed pistons. He will pay a visit to Buenos Aires.

MR. ADOLPHE S. A. CORIN is retiring on April 1 after over 40 years' service with the Société Anonyme John Cockerill, of Seraing, Belgium, as their agent in this country. He reached the age limit in 1940. During his business career, Mr. Corin carried out missions for his principals in the Far East, the Scandinavian countries, etc. Mr. Corin's father joined the Société Cockerill in 1845, at the age of 11, so that father and son, between them, have been connected with the firm for over 100 years. Mr. Corin is vice-president of the Belgian Benevolent Society and a member of the Committee of the Belgian Chamber of Commerce in London. He will be succeeded, as agent for the Société Cockerill, by CAPT. W. V. DAUPPE, who, in pre-war days, was in London as a partner of A. C. Cochenet, well known in the steel trade. He joined the Belgian Army in August, 1939, returned to this country through Dunkirk, and later joined the Commando Brigade. He saw fighting in Italy, Yugoslavia, Normandy, Holland and Germany. Since the cessation of hostilities, until recently, Capt. Dauppe was a buyer of raw materials at the Belgian Economic Mission in London.

Wills

SMITH, DAVID, of Pollokshields, Glasgow, retired iron and steel merchant	£21,665
BENNETT, C. S., formerly of Hagley, Stourbridge, late chairman of Gibbons (Dudley), Limited ...	£33,010
ROBSON, P. W., chairman of Alex. Findlay & Company, Limited, structural engineers, Motherwell...	£62,106

IN PARLIAMENT

Iron and Steel Industry in Lanarkshire

MR. TIMMONS asked the Minister of Supply and of Aircraft Production if he was in a position to state in detail, what form of reorganisation was to take place in the iron and steel industry in Lanarkshire.

MR. WILMOT: The plan prepared by the British Iron and Steel Federation for the future of the iron and steel industry is at present under consideration, and I regret, therefore, that I am not yet in a position to make any statement as to the future organisation of the industry in Lanarkshire.

Iron-ore Freight Subsidy

MR. GAMMANS asked the Minister of Supply and of Aircraft Production whether any subsidy was at present being paid in respect of ships bringing iron ore from North Africa to the United Kingdom.

MR. WILMOT: At the present time a freight subsidy averaging about 19s. per ton is being paid by my Department on iron ore imported from North Africa.

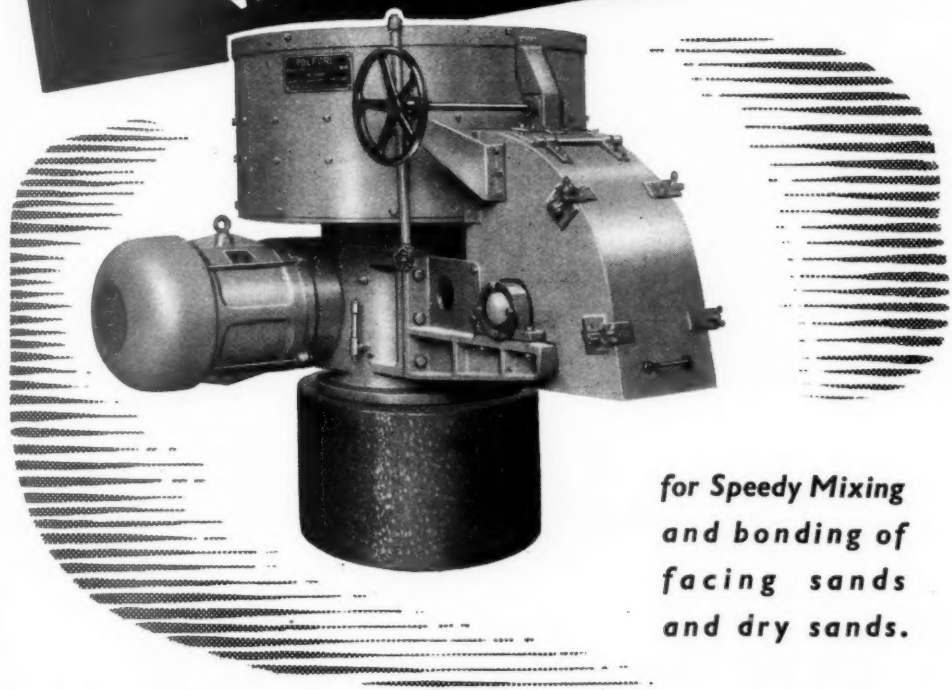
ELECTRO-TINPLATE

A device permitting microscopic observation of an electro-tinplate surface during the fusion process has been developed at the Armour Research Foundation of Illinois Institute of Technology. According to H. J. FRANCIS, of the Institute, a photographic record of fusion is obtained by attaching a 16-mm. motion-picture camera to the microscope. The resulting pictures enlarged show clearly the process step by step.

THERE WERE SO MANY RUMOURS in one large American factory during the reconversion that the management placed " Rumour Boxes " in all the shops asking employees to deposit therein all the mentally disturbing stories they had heard. Next day the boxes were empty, but the general morale was distinctly better.

PAT. Nº 570997

"POLFORD" REGISTERED MOTOR DRIVEN MIXER MILLER WITH DISINTEGRATOR



for Speedy Mixing and bonding of facing sands and dry sands.

SOLE AGENTS :

THOS W. WARD, LIMITED. Albion Works, Sheffield

TELEPHONE: 26311 TELEGRAMS: FORWARD SHEFFIELD

NEWS IN BRIEF

THE CONSTRUCTIONAL ENGINEERING COMPANY, LIMITED, of Titan Works, Charles Henry Street, Birmingham, 12, announce that their London office is now at 92, Victoria Street, S.W.1. Mr. K. S. Brown is in charge of export sales.

THE PARTNERSHIP BETWEEN Mr. Sidney R. Adamson and Mr. Frank Turner, welding specialists, carried on under the name of Adamson & Turner, at Firth Street, Huddersfield, has been dissolved. Mr. Turner is to carry on the business under his own name.

PRIVATE TRADE between the United Kingdom and Malaya is now permissible in goods for which the Malayan authorities have granted an import licence, subject, of course, to compliance with any export licensing or other requirements in the United Kingdom.

IT IS THE INTENTION to hold the British Industries Fair in the first half of 1947. A committee under the chairmanship of Lord Ramsden has just reported on the policy and plans for future exhibitions and fairs. The report is now being considered by the Board of Trade.

WHOLESALE PRICES IN JANUARY, as measured by the Board of Trade index number, rose by 1.7 per cent. compared with December, the first upward movement since last July, and the largest monthly rise since November, 1940, when the full effect of price control began to be apparent.

COOPER & TURNER, LIMITED, of Sheffield (Vulcan Rivet and Brass Works), have disposed of their brass foundry to William Wild & Sons, Limited, Midland Brass Works, Attercliffe, Sheffield, to provide for extensions in other directions. Wild & Sons have also taken over the foundry workers.

TEES VALLEY WATER BOARD was told last week that approximately 42 million gallons of water per week would be required by Imperial Chemical Industries, Limited, for their new factory at Wilton. Subject to the grant of statutory powers, the Board agreed in principle to promote a scheme for the provision of the necessary works and plant.

THE FIRST British civilian aircraft to be supplied to a private home source since the war was delivered to Mr. C. D. Macartney-Filgate, a director of Tube Investments, Limited, on February 2. The aircraft (a Taylorcraft 3-seater, high-winged monoplane) has been acquired by Mr. Macartney-Filgate to speed up journeys to production conferences and consultations at the group's distant works, which are spread across the country, and to make possible quick personal contact with customers on the Continent and in the British Isles.

THE CODIFYING AND SIMPLIFYING of income tax so that a business man can compute his liability without professional advice if he wishes, is one of the recommendations made to the Chancellor of the Exchequer in connection with his forthcoming Budget by the National Union of Manufacturers. The memorandum, which is submitted on behalf of 4,000 manufacturers, urges that the Budget should be framed to act as an incentive to the attainment of a state of full production and full employment. It is recognised that certain controls on manufacturers are for the time being necessary, but the Union urges that every possible step should be taken to reduce the number of controls to the absolute minimum and to leave the manufacturer freely to exercise his skill and ingenuity in the production of British goods for sale throughout the world.

CONTRACTS OPEN

Any date given is the latest on which tenders will be accepted. The address is that from which forms of tender may be obtained.

Dagenham, February 28—Steel reinforcement fabric, for the Borough Council. Mr. A. E. Stickland, borough engineer and surveyor, Civic Centre, Dagenham, Essex.

Dewsbury, March 4—Iron castings, steel reinforcements for the Borough Council. Mr. E. Shaw, borough engineer, Municipal Buildings, Halifax Road, Dewsbury.

Morley, March 1—Sewerage iron work, for the Borough Council. Borough Engineer's Office, Town Hall, Morley, Yorks.

Ogmore, March 6—Manhole covers and other castings, for Ogmore and Garw Urban District Council. Mr. A. H. Jenkins, engineer and surveyor, Council Offices, Brynmenyn, Glam.

Stoke-on-Trent, February 28—Cast-iron work, cast-iron pipes and specials, general ironware, etc., for the Corporation. The City Surveyor, Town Hall, Stoke-on-Trent.

Tynemouth, February 25—Cast-iron work, iron pipes and fittings, iron and steel, for the Borough Council. The Borough Surveyor, 19-20, Howard Street, North Shields.

COMPANY RESULTS

(*Figures for previous year in brackets.*)

Mather & Platt—Net profit for 1945, £184,154 (£172,294), after taxation; final dividend on the ordinary stock of 6%, making 10% (same).

Davies & Metcalfe—Net profit for 1945, after depreciation and tax, but including interest, dividends, etc., £13,788 (£15,118); final dividend of 8%, making 11% (same).

Delta Metal—Profit for 1945, £212,529 (£213,086); income-tax provision, £135,000 (£140,000); balance, £77,529 (£73,086); ordinary dividend of 12½%, plus a bonus of 7½%, both tax free (same).

R. B. Pullin & Company—Profit for the year ended September 30, 1945, £51,627 (£82,420 for 11 months to September 30, 1944); provision for tax, etc., £37,975 (£68,774 for 11 months); to general reserve, £4,000 (£5,000); dividend of 17½% (same).

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for all Types of
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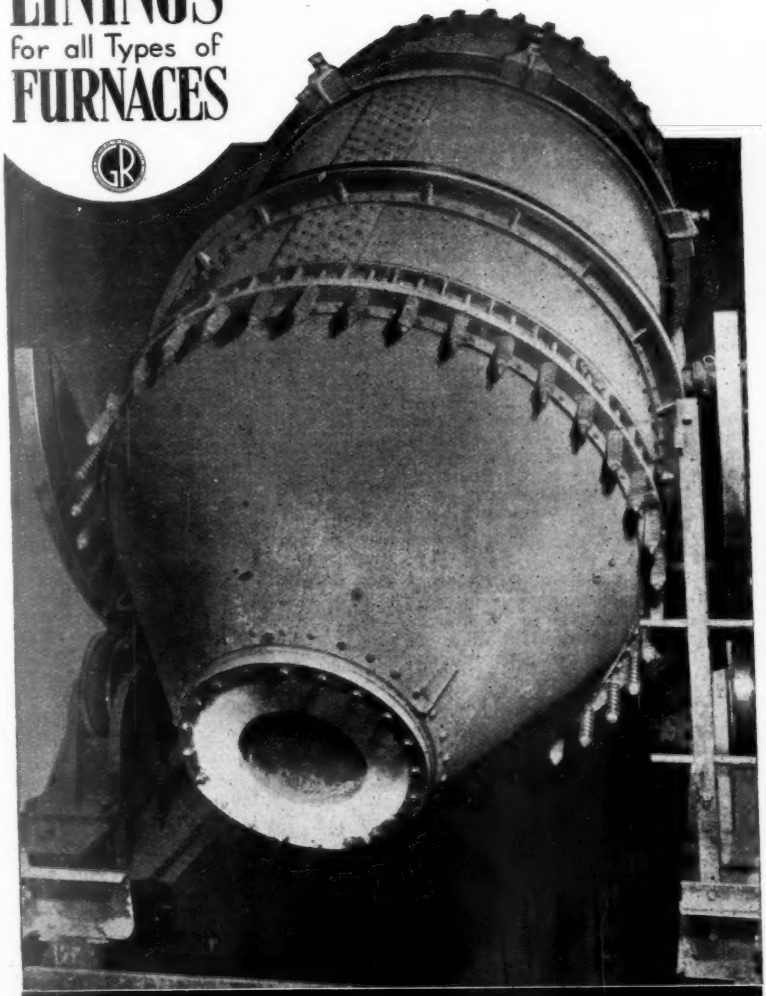

General Refractories Ltd
Head Office: Genefax House, Sheffield, 10. Telephone: 31113 (6 lines)

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Raw Material Markets

IRON AND STEEL

An indication of still more restricted supplies of industrial fuel is not a happy augury for the iron trade. For some time past foundrymen have been insisting that a bigger output of high-phosphorus iron will be needed if they are to provide the enormous quantities of light castings for which the building and other trades are clamouring. There are plenty of blast furnaces which could be put into operation if coke could be provided, but until this condition can be fulfilled the prospect of a bigger output of pig-iron must be remote. Current production of high-phosphorus iron seems to be keeping abreast of foundry requirements, but there is certainly no surplus, and in some cases applications for licences have had to be procured. Supplies of hematite, refined, and low- and medium-phosphorus grades are more plentiful, but surpluses are not substantial and are being held in reserve to meet future contingencies.

The maintenance of deliveries of steel semis to the sheet works and re-rolling mills in tonnages sufficient to enable the makers of bars, light sections, strip, and black and galvanised sheets to meet their heavy commitments is a task which demands unceasing vigilance. Unaided the British steelmakers are unable fully to satisfy all requirements. On the other hand, the authorities, fully apprised of the shortage of foreign credits, are naturally anxious to keep imports down to the minimum. It is a situation which calls for careful discrimination based on exact statistical knowledge, and past experience does not discourage the hope that the position will be kept under control.

Production of steel plates, joists and sections is not up to attainable limits, but more labour, more fuel and better transport facilities will have to be provided before optimum outputs are achieved. Meanwhile, works are so heavily booked that there is not much scope for the acceptance of further orders, though there is an abundance of business on offer.

Buyers of black and galvanised sheets have to reconcile themselves to long waiting periods before they can expect delivery, and the pressure for steel rails, boiler plates, etc., is intense. There is rather more inquiry for alloy steels, but these can still be provided at short notice.

NON-FERROUS METALS

The world copper situation remains unsettled, although several factors have recently come to light which have given a possible indication as to future dealings in the copper market. The Ministry of Supply is apparently negotiating for the purchase of about 40,000 tons of South American copper, at a price of around 12 cents per lb., f.a.s. producer's port. When it is appreciated that Empire copper has been bought at 11.75 cents per lb. (New York basis), f.a.s., it seems obvious that any future supplies to this country could not be sold economically by the Ministry at the officially controlled price. This points, therefore, to an early raising of the price of copper in this country. It is reported that the American Government is definitely buying 20,000 tons of foreign copper a month.

Malayan tin-mining concerns are to get financial assistance from the Government, which should greatly assist the industry to get on its feet again as quickly as possible.

Many lead consumers in this country express anxiety at the apparently deficient quantity of metal purchased by the Government. It is unfortunate that manufacturers are having to restrict production in the face of the uncertain position; in consequence, a considerable volume of export trade is having to be turned away.

NICKEL FLASHING OF ENAMEL STOCK*

A flash nickel coating is one method used to avoid dark coloured cobalt enamels. Fluoride treated nickel plating baths have the advantages of cleanliness, crystal fineness, elimination of passivity and stabilisation of *p*H value over normal sulphate baths. The optimum amount of nickel varies with the type of enamel; it is 0.05 g. per sq. ft. for zircon enamels and 0.08 for antimony enamels. The nickel flash as applied to the steel is chiefly metallic nickel with small amounts of nickel hydroxide or nickel oxide.

The role of nickel in developing enamel adherence is apparently bound up with its retardation of the oxidation of the iron during the enamelling and its effect on the nature of the iron oxides formed. Probably enamel adherence may be considered a corrosion phenomenon of the base iron developed by the action of the gases and other agents which may be present at the enamelling temperatures. As such, the degree of adherence is a function of the oxygen pressure at the interface when the glass is fused.

The adherence promoting oxide on steel sheet appears to be FeO at the enamelling temperature. At this temperature the FeO is formed under certain equilibrium conditions, which are obtained through the presence or formation of a material, probably a metal, taken from the group known as adherence promoters, which acts as a stabiliser for the continued development of FeO.

The bond at room temperature will consist of a mixture of the stabiliser material, probably metal, iron and Fe_3O_4; the latter two are the result of the decomposition of FeO on cooling. An alloy of iron and the stabiliser metal possibly may form the adherence promoters in the glass. For the adherence to be effective, certain equilibrium conditions must be met.

A LETTER FROM AUSTRALIA tells us that Mr. Robert Mason, who, from the inception of the Institute of British Foundrymen until 1912 was a prominent member of the Birmingham, Coventry and West Midlands branch, is still, at the age of 81, actively engaged in business as an iron and steel founder with the firm of Mason & Cox, Limited, Adelaide.

* "Materials and Methods" abstract of a Paper by E. Wainer and W. J. Baldwin.